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FLIGHT

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## Gentlemen—the President

AMONG the few dominant figures of the British aircraft industry that of Sir George Dowty stands apart, if only by reason of his comparative youth. He is 59. Recording this, "Observer" in *The Financial Times* writes: "Dowty's began with an article about internally sprung aircraft wheels in *Flight* 30 years ago. The contributor was a bright young engineer with the Gloster Aircraft Company. His article was read by the managers of Kasawaki, a Japanese aircraft firm, and they wrote to *Flight* for further details."

We read these lines with especial pride because, in addition to his other attainments, Sir George has now taken office as president of the Society of British Aircraft Constructors. The bright young *Flight* contributor leads the leaders.

## Thoughts After Farnborough

THIS year a Saab Draken appeared in the SBAC Display. In the abstract, it is true; for its shape was represented by one of the new formations of Treble One Squadron. Next year—who knows?—Sweden's double-delta fighter may well be there as solid hardware; for more and more people are expressing the opinion that foreign aircraft having British engines or largely equipped by British manufacturers should be allowed admittance.

The idea makes a great deal of sense at a time when liaisons, liberalization, licensing agreements, co-operative enterprise, sub-contracting and common marketing are forming new industrial and national structures. Thus, Farnborough might ultimately become another (we decline to write "second") Le Bourget, and the two might alternate in a sort of balance of power for the dominance of European aeronautical affairs.

At least this was one of the possibilities that were being discussed in emancipated and enlightened Farnborough circles. Certainly, both in calibre and numbers our overseas visitors rendered the show more strongly cosmopolitan than ever before, according well with the suggestion we made last week that Farnborough should be an occasion for international as well as national discussion and inquiry. In line with another of our recently stated views, the president of the SBAC alluded at the Farnborough-week dinner to foreign competition in the civil field, which he described as "severe." At the same time Sir George—realist that he is—proclaimed that it was fortunate at this time to find an increasing demand for people and goods to be transported more quickly and with greater economy. Reduction in the cost of travel, he said, could capture a still greater market. Which leads to a new appraisal of our civil-transport prospects as represented at Farnborough—equally in the static exhibition as on the airfield. Economy as demanded by Sir George will stem largely from judicious application of the turbofan, of which Rolls-Royce and Bristol Siddeley are offering the pre-eminent examples. In this issue we give new particulars of the Avro 771 and BAC-107, which are Britain's new contenders for the small-jet transport market, and in doing so we remark that it is the turbofan engine which is now seriously challenging the short-range economic preserves of the turboprop. Yet in applauding the achievements of British engine designers we shall be wise not to forget that, whereas neither the Avro nor the BAC aeroplane could be in service before 1964 at the earliest, the Soviet Union has had a comparable machine flying for weeks or months. We earnestly hope that the contending British designers are having a close look not only at one another's Farnborough brochures, but at the figures for the Russian aircraft given in *Flight* of July 22 last.

*MILITARY COUNTERPART of the Soviet An-10 airliner has a rear-loading ramp and tail gun position reminiscent of the little-used An-4. This photograph, newly received, shows an example with civil registration*

# FROM ALL QUARTERS

## The SBAC Dinner

THE new President of the Society of British Aircraft Constructors, Sir George Dowty, said at the SBAC annual dinner in London on September 7, "As a representative of the equipment industry I am proud of the success of this side of British aviation, which perhaps tends to lose its identity in an industry primarily thought of in terms of complete aircraft or aero-engines." Sir George warned that we may have to face a decline in our aviation exports, however, for everywhere we saw a downturn in orders for military aeroplanes. It was fortunate at this time when we wanted to expand our civil business, he said, to find an increasing demand for people and goods to be transported more quickly and with greater economy. There were many matters to be resolved before we could start a supersonic airliner project. Of air freighting Sir George said, "So far we have only scratched the surface of air freighting of cargo, a field where great opportunities lie, for although I have referred to the recent expansion that has taken place in this business, yet it is interesting to note that only 5 per cent of our country's total exports are currently being airfreighted."

Sir George went on to refer to the new structure of the industry in these terms: "Our first Minister will be remembered as the architect of our new industrial structure which, we hope, is now better able to withstand the stresses of a highly competitive market. In a short time he effected a remarkable transformation but it must be said that this was made possible by the full and ready co-operation he received. . . .

"Tonight we welcome our new Minister. He takes over his important office with our good wishes. His record is a most distinguished one and we have great confidence that he will be an inspiration to us all and follow up the work of his predecessor by giving us that help and encouragement so necessary for the success of this important industry."

Sir George thanked the Minister for the hospitality provided by Her Majesty's Government on the previous evening—a further indication, he said, of the keen interest of the Government in SBAC affairs.

Replying, Mr Peter Thorneycroft, Minister of Aviation, said: "I was once the guardian of the public purse and I now find myself head of a great spending department. All are familiar with the poacher turned gamekeeper, the man with a shady past who has become a figure of honour and respectability. The gamekeeper turned poacher is a situation requiring rather more delicacy in explanation. In these circumstances may I say first a word of encouragement to the British aircraft industry. You are assured of our continued support. Do not despair, a little money may still trickle through to you. I recognize that what the Ministry of Aviation does will remain and rightly remain expensive. We must rid it of the label of being extravagant."

Of spaceflight the Minister said: "For the United Kingdom alone to seek to compete in the field of manned space vehicles with Russia and the United States would certainly be imprudent and probably impossible. There are, however, spheres of space research, commercial, technical and scientific, which fall far short of this. If such research and development, whether in the field of satellites or launchers, is to be carried on outside the United States and Russia, let us at least make an effort in the Commonwealth and in Europe to find a co-operative basis for it. If we are to look towards the stars let us look a little beyond our own national frontiers first of all."

The Minister said of supersonic transports: "There is apparently a limited market for supersonic commercial aircraft. If one of us goes into it, we may well all attempt it, and I am bound to say that I believe, in this country, we would do it very well. There is, however, in this supersonic field, a powerful case for all of us agreeing what to make, when to make it and then making it together. Our studies of a supersonic civil aircraft are indeed well advanced and will soon be advanced still further. We are very ready to consider how we might collaborate with the Americans, the French, or other overseas friends who are interested."

## C. F. Uwins for Shorts

THE MoA announces that Mr C. F. Uwins has been appointed to take charge of Short Brothers & Harland Ltd as chairman and managing director until December 31, pending a permanent appointment. For several years Mr Uwins has been a director of Shorts and he is also a deputy chairman of the Bristol Aeroplane Co Ltd, an office which he will continue to hold.

In the earlier years of his career Mr Uwins was one of the most noted test pilots, not only of this country but in the world.

## US Navy's 500km Record

A NEW speed record of 1,216.78 m.p.h. over a 500km closed circuit (about 313 miles) was set up by a US Navy McDonnell F4H-1 Phantom II over a triangular course at Edwards AFB, Cal, on September 7. If accepted by the FAI, this will exceed by more than 400 m.p.h. the current world record for a 500km course, set up by Capt George Edwards of the USAF in an RF-101 Voodoo on April 16, 1959. The Phantom II was piloted by Lt-Col Thomas Miller.

## Russian VTOL Projects

ACCORDING to a recent Moscow radio broadcast, Soviet aircraft designers are now working on a number of VTOL projects. One of these, described as a coleopter, first rises to a height of about 100m (330ft) before making its transition to horizontal flight. Another "takes off like a helicopter, then moves forward on a separate engine." A third design is apparently of the tilt-wing type, and a fourth is a variant in which only the engines are tilted. The broadcast concluded by saying that these projects would go into serial production "in a very short time."

*RIVER HELIPORT: On the Westland stand at the SBAC Show last week was this model of a proposed London heliport, built out over the Thames between Waterloo and Blackfriars Bridges. Note the two "long-span" Rotodyne models; a close-up of one of them appears on page 448*

***HIGH, COLD AND LONELY:** Koen Jansen and Alfred Eckert, with an intrepid journalist, waving to "Flight's" Gemini at 8,000ft just east of Coxyde on their Channel crossing from Ferryfield to Bruges in the balloon Augusta VIII on September 2. We reported their position and progress to Calais and Ostend, apparently the last such report that evening. British Oxygen had supplied 37,000 cu ft of hydrogen to inflate the envelope*

## Gnat All-through Trainer

WITH the above designation, Folland have proposed a version of the Gnat Trainer which could be fitted with a straight wing of 183 sq ft area and 12 per cent t/c ratio allowing 80kt landing and M0.81 maximum speeds. The swept wing would be interchangeable with this and a larger tailplane. The project should meet Continental moves towards the "1½" trainer covering the complete *ab initio* to operational aircraft sequence.

## Anglo-French Gearbox Agreement

THE firm of Dowty Rotol, who in recent weeks have received orders for aircraft accessory equipment worth nearly half a million pounds, announce a ten-year agreement with Hispano-Suiza under which the French company will licence-manufacture Dowty Rotol gearboxes for Rolls-Royce Tyne engines for the Breguet 1150.

## Hunting Aircraft Board

IT is announced by the British Aircraft Corporation Ltd that all formalities in taking over a controlling interest in Hunting Aircraft Ltd have now been completed. Sir George Edwards and Mr W. Masterton have been elected to the Board, and Mr G. L. Hunting and Mr R. R. S. Cook have left it. The composition of the Board is now: Sir Percy Hunting, chairman; Sir George Edwards, CBE, BSC, Hon FRAeS, Hon FIAS, vice-chairman; Mr C. P. M. Hunting, TD, BA, FCA; Mr L. C. Hunting, MA; Mr William Masterton, CA; Mr W. A. Summers, CBE, FRAeS, MIProdE, managing director; Mr K. D. Morgan, FCA, secretary and commercial director; Mr F. W. Buglass, MIProdE, works director; and Mr F. H. Pollicutt, FRAeS, AFIAS, technical director.

## Westland Narrows Range

THE four main types of helicopter on which Westland Aircraft Ltd will concentrate development in the immediate future are the Rotodyne, Wessex, Gnome Whirlwind and P.531 Sprite, with project work continuing on the Belvedere. In a policy statement made during the SBAC Show at Farnborough, a company spokesman said that the Westminster would be "on ice" after completing its demonstrations during Farnborough week.

It appears probable that a joint company/MoA effort will be made towards obtaining a C of A for the Rotodyne. This, it is believed, could be obtained by 1965. In addition, the company is putting forward a tender for the Rotodyne to meet an RAF requirement for ten 60-seat troop transports. An interim civil version of the Belvedere, the 192C, could be available by 1962, and could be followed by the 60-seat Type 194.

Some reduction in the number of types actively being developed and produced by the company has been an expected step since Westland acquired the helicopter products of Bristol, Fairey and Saunders-Roe. The aircraft now omitted in the company's future planning are the Westminster, Widgeon, piston-engined Whirlwind, Skeeter and Sycamore.

## First Rotorcraft Section Dinner

REPLYING for the 500 guests at the first annual dinner (held in London on September 8) of the Rotorcraft Section of the Royal Aeronautical Society, Mr H. D. N. Wyatt, chairman and managing director of British United Airways, made some significant remarks about commercial helicopter services. Quite soon, he said, helicopters might be operating profitably between cities in Britain and the Continent and the costs could be met with a good-sized "bus machine" and good route network. A major cost item would be short replacement life and he suggested that a replacement hiatus of ten years "would make us home and dry." Depreciation rates of 25 per cent per year would render operations unprofitable; between seven and ten per cent were reasonable.

Proposing the health of the section, which was holding its first annual dinner since it became part of the RAeS (it was formerly the Helicopter Association), Dr E. S. Moult, president of the Society, said that the special capabilities of the helicopter in the VTOL and STOL field were now being appreciated. The newer vehicles did not foreshadow the end of the helicopter with its weight-lifting and low slipstream-velocity characteristics.

The guests were welcomed by Prof J. A. J. Bennett, president of the section, and Dr Moult presented the Alan Marsh Memorial Medal to Flt Sgt B. Breach of No 228 Sqn for his rescue by Sycamore of the crew of a drifting lightship off the Scottish coast. The Alan Marsh Memorial Award went to Mr A. C. Jolly of the Saunders-Roe division of Westland.

## IN BRIEF

A speed of 2,112 m.p.h. was reached by Maj Robert White in the X-15 on September 10 in a descent from 80,000ft.

It was announced last week that a full transport-category certificate of airworthiness had been issued to the Armstrong Whitworth Argosy for the carriage of passengers and freight. The Avro 748 has also received a special-category C of A after a total flight time of 70hr. It was awarded last week.

All civil flying in North America was banned for six hours on September 10—for the first time in peacetime—when Exercise "Sky Shield" was mounted by NORAD, the joint US-Canadian Air Defence Command. A total of 2,000 sorties was being flown by defending aircraft.

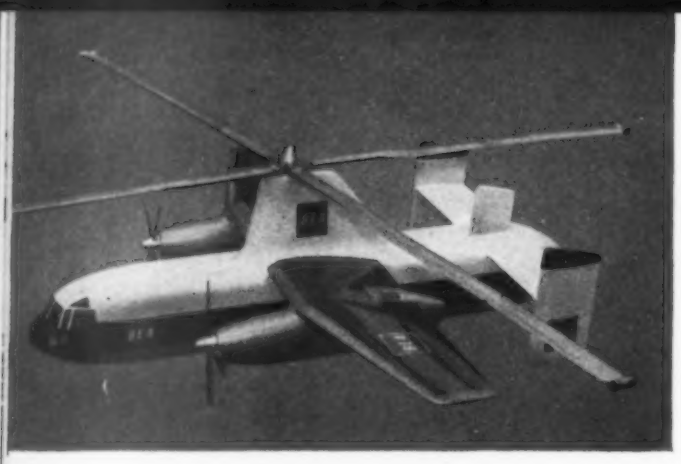
Mr Harold J. Downes has been appointed director of international operations for Lear Inc, the American electronics firm. For the past two years he has been co-ordinator of international sales and licensing for Lear's six divisions.

Coincident with the announcement that the USAF is increasing its order for North American T-39 Sabreliner UTX trainers to 94 aircraft, the makers state that the first production machine has flown 1,820 miles non-stop on internal fuel. Powerplants are Pratt & Whitney J60 turbojets.

Mr Hugh H. Bowe has been appointed director of European operations for Republic Aviation Corporation, with headquarters in Paris. He was with the USAF, as head of the Aircraft and Missile Division of Air Materiel Command, until joining Republic two years ago as deputy director.

***MAJ C. H. VALLANCE** (left), new sales manager of Blackburn Aircraft, whose sales staff he joined in 1957. At present based in London, he is shortly moving up to Brough*

***MR D. S. SCOFFHAM** (right), formerly Bristol's deputy sales manager (fixed-wing aircraft), has joined Short Bros as manager, technical sales, Britannic. He will operate from Shorts' London offices, East India House, 208a Regent Street, W1*



***THE ROTODYNE'S WINGS GROW:** Close observers of the Rotodyne model (in BEA colours) on Westland's stand at the recent SBAC display will have noticed the considerable increase in wing span—now extended by 18½ft to 75ft. Fuselage is also 4ft longer. Other changes: redesigned rotor-head, tip-jets, cockpit canopy, and fins and rudders (with the third fin as standard); deletion of the rudder bracing strut; and a repositioned Tyne efflux. BEA's latest views on the Rotodyne were recorded in "Flight" for September 2, page 327*

# AIR COMMERCE

## SIR WILLIAM'S ANNUAL REPORT

"I CAN imagine no unhappier issue than the production of a supersonic aircraft which the airlines cannot operate with any hope of economic success and which will therefore be an economic disaster for the manufacturers." This quotation comes from the annual report of Sir William Hildred, director-general of IATA, delivered at the 15th a.g.m. of the Association which opened in Copenhagen last Monday, and which ends today, September 16.

He thinks it "imperative" that the airlines should take the initiative in trying to produce "the best possible supersonic transport which they know they can handle before other considerations shape the aircraft in other and less favourable directions." The 14th IATA technical conference next spring would be the occasion for a Supersonic Symposium to co-ordinate ideas on the operating and the economic requirements of the airlines. Invited to the supersonic symposium were representatives of governments, manufacturers and other international organizations, including ICAO, which had already carried out "a valuable study [see pages 449, 484 and 485 of this issue] of the subject."

Sir William hopes that no one will be "panicked into producing or accepting a supersonic aircraft before we have had a chance to digest the jets and equip ourselves for the even more demanding transition ahead." He has an additional reason for approaching the subject "with deliberation and care"—he has "a strong feeling" that the nuclear-powered aircraft might not be so far away as might generally be thought.

In his annual report Sir Wiliam also has something to say about jet noise: indeed rather more than one-fifth of the report is devoted to the subject. In particular he says: "We can pay ever closer attention to the state of our day-to-day community relations. Experts in this field have found that communities which believe that their airport authorities and airlines are doing a competent and sympathetic job manifest a 30 per cent greater tolerance towards noise than do those in which the authority has not minded its public relations."

Sir William also has something to say about airline pooling and co-operation. Having put the case for these agreements as "inevitable and necessary," he says: "But we must not forget that the public has other requirements and desires besides those of cost"; and he hopes that airlines will avoid any tendency to underschedule and to diminish that touch of individuality in service which helps to keep air transport interesting, progressive and dynamic. "The final touchstone of any co-operation agreement is whether it results in more efficient and economical service to the public without detracting from its convenience and attraction, and from those touches of personality which the particular public has learned to expect."

## HERALDS FOR JERSEY AIRLINES

IN a surprise statement on the second day of the SBAC display, Handley Page announced that an order has been placed by Jersey Airlines for six Dart Heralds. This is the first firm order for the Herald to be placed by an airline, the three intended for BEA having been ordered—as yet provisionally—by the Ministry of Aviation. The contract, worth about £1¼m excluding spares, was signed on September 7 by Mr M. L. Thomas, chairman and managing director of Jersey Airlines.

The version ordered is the stretched Herald accommodating 50 seats. The extension, reported last week, amounts to 42in to the forward fuselage, and the 50-seat layout allows for a large buffet, toilet and 340 cu ft of cargo space. Jersey Airlines have six DC-3s and six Herons, and it is expected that a number of Herons will become surplus first, DC-3s having been taking over Heron routes as Jersey's traffic has expanded.

Though BEA has a 25 per cent shareholding in Jersey Airlines, there is no connection between this order and the Heralds that may be bought by the MoA for BEA. The first and second Jersey Airlines' aircraft are due to be delivered next June to meet the airline's summer traffic demands; and in June 1962, two more —possibly four more—will be delivered depending on traffic. If only two are delivered, the remaining two will be handed over in June 1963.

Negotiations have been going on between Jersey and Handley Page for three months, and Jersey Airlines have studied closely both the Friendship and the Avro 748. One of the factors that inclined Jersey Airlines to the Herald was the increased capacity of the stretched version, which could well be the Herald that will now be emphasized by HP. Mr Thomas told *Flight* last week that, in his view, this stretch gives the Herald "great possibilities," and it certainly made the aircraft ideal for his airline's routes. Jersey Airlines connects the C.I. with Paris, Dinard, St Brieuc, Gatwick, Southampton, Bournemouth, Manchester, Coventry and Exeter.

As reported in last week's issue, certification of the Herald is expected by the end of 1960 at an initial all-up weight of 39,000lb, approval for 40,000lb being expected shortly afterwards. Tropical trials have shown that certification may be expected at 39,000lb in tropical temperatures (ISA+30°C) compared with the ISA+22°C previously expected. Performance at 40,000lb can be maintained at ISA+13°C.

So far as BEA aircraft are concerned, notwithstanding the fact that the contract has still not been signed by the Ministry of Aviation (see last week's issue) Handley Page are going ahead at Reading with production of the first BEA aircraft which, they say, will be handed over to BEA towards the end of January 1961. The two others will follow in February.

## MEA's COMET DATE IS NOVEMBER 1

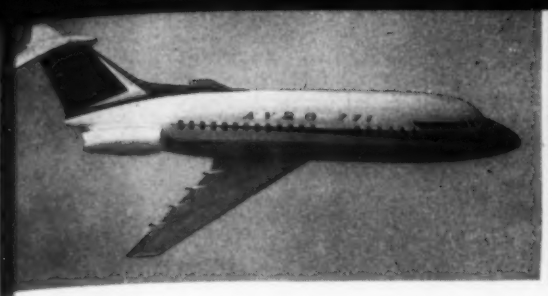
BY chartering two weekly Comet 4 services from BOAC between London, Beirut and Dhahran, MEA have brought forward by two months their target date for the introduction of Comet services. When MEA's order for four Comet 4Cs was announced, it was said that first delivery would be on December 15.

The chartered aircraft will bear "temporary MEA markings," and the contract is to continue until the end of March 1961. This, say MEA, "will cover the introduction of MEA's own Comets into commercial service." Delivery of the first MEA Comet is still planned for December 15 and the type will start regular services on January 6. MEA flight and cabin crews will serve as supernumerary staff on the BOAC flights to gain experience before MEA's operations begin. All MEA's Comet 4Cs will have been delivered and put into service by the end of March, i.e. on expiry of the charter contract with BOAC.

## MR QUESADA IN TOWN

ANGLO-US co-operation in the development of a supersonic transport was agreed in principle in London last week by the MoA and a six-man delegation from the FAA, led by Mr E. R. Quesada. The administrator and his team, now in the USSR on an exchange visit, agreed that "further consideration" should be given as to how co-operation could be achieved in practice. There is also to be co-operation on (1) North Atlantic ATC studies; (2) long-range navaids; (3) air/ground data link requirements; and (4) FAA evaluation of BLEU automatic landing.

Anglo-US technical co-operation is, of course, going on all the time; earlier this year a four-man UK delegation comprising two operations and telecommunications specialists, a scientist and an RAF officer worked with the FAA in America. At the moment a three-man exchange mission from the FAA is working with the Ministry of Aviation. The main aim of this co-operation, say the Ministry, is "to collaborate in the development in the two countries of systems which are compatible; and if possible to achieve some economy of effort by co-operative development in both countries."



# Avro 771 and BAC-107

STRIKINGLY similar in their general appearance, the two new British small jet transport projects—the Avro 771 and the BAC-107—can now be compared in closer detail. Both are based on a rear-engined powerplant comprising two Bristol Siddeley BS.75s of 7,350lb st thrust each, a new turbofan whose remarkable economy was the subject of a note last week (p. 420). It is this engine, in fact, which is now seriously challenging the short-range economic preserves of the turboprop.

In general both aircraft may be considered as replacements for the large Viscounts, offering the same order of seat-mile costs—possibly less if first cost can be kept below that of the Viscount 810 (i.e., less than £500,000)—but with considerably higher productivity and 50 per cent more speed.

The BAC-107 (which originated three years ago as Hunting Aircraft's H-107, and which is now being jointly developed with Vickers as a BAC project) is slightly larger all round, having roughly 4ft more length and span. Its wing area is also slightly greater. The most notable differences are in maximum take-off weight and design cruising speed. The lower weight and rather greater wing area of the BAC-107 produces a wing loading of about 59lb/sq ft compared with 65lb/sq ft for the Avro 771. Unlike the 107, the Avro project is going to have leading-edge high-lift devices. The 771's wing has 10deg more sweep, conferring a design Mach number of 0.82 compared with 0.75 for the BAC-107.

One or two apparent anomalies in the table here (which was compiled from data available at Farnborough) could well be attributed to differences in assumptions. BAC say on the question of cruising speed: "Detailed investigations have been made of the possibilities of alternative BAC-107 designs with higher cruise performance. These studies have shown conclusively that very small block time reductions would be achieved, and that the concept of an inexpensive, simple jet airliner would virtually disappear in the process." Both aircraft could be available in 1964.

| | Avro 771 | BAC-107 |
|---|---|---|
| **Powerplant** | 2 × BS.75 of 7,350lb | 2 × BS.75 of 7,350lb |
| **Seating** | 42F*, 60E | 50F*, 59E |
| **Dimensions:** | | |
| Length | 80ft 4in | 84ft |
| Cabin internal width | 9ft 11in | 10ft |
| Cabin height | 6ft 6in (min) | 6ft 5in |
| Cabin length | 44ft 4in | 48ft 8in |
| Span | 77ft 6in | 81ft 8in |
| Wing area | 800 sq ft | 825 sq ft |
| Height | 24ft 3in | 23ft |
| Sweepback (¼ chord) | 30° | 20° |
| **Windows per side** | 20 | 26 |
| **Weights:** | | |
| Max take-off | 52,000lb | 48,500lb |
| Max landing | 50,000lb | 46,000lb |
| Max ZFW | Not available | 41,000lb |
| Max payload | 12,000lb | 12,000lb |
| **Fuel Tankage** | 2,000 Imp gal | 2,230 Imp gal |
| **Performance:**** | | |
| Take-off field length | 4,800ft (water inj) | "less than 5,000ft" |
| Landing field length | 4,500ft (47,000lb) | |
| Approach speed | 109kt (47,000lb) | 110kt |
| Cruising speed | 495kt (M0.82) | 440kt (M0.75) |
| Max payload range† | up to 500 n.m. | 435 n.m. |
| Cruising height | 25,000ft (6.5lb/sq in dP) | 30,000ft (7lb/sq in dP) |
| **Price** | "less than £½m" | "less than £½m" |

*36in pitch, four-abreast. **Standard conditions. †With realistic reserves.

## SUPERSONIC IMPLICATIONS

**"It is important that in the intervening years [before the advent of a supersonic airliner] opeators and their governments prepare plans and co-ordinate development in a manner that will assure the orderly development of air transport without detrimental effects to the travelling public or the airlines, and to the advantage of the peoples of the world. Here ICAO will have to perform the role called for in its charter."***

BECAUSE private finance on the necessary scale is unlikely to be available for a supersonic airliner, direct government financial support will therefore be required. Though there is nothing new in this suggestion, which comes from ICAO's recent study of the implications of the supersonic airliner, the suggestion that follows—very carefully phrased as befits a document of supranational authorship—is new.

"There are," says the report, "a number of economic considerations that might cause governments to postpone the start of the development work." Obviously a document such as this cannot say what it thinks governments *ought* to do; instead it says that governments (who after all hold the purse strings) "might wish" to take a number of economic factors into consideration. These are as follows:—

(1) by allowing military experiments with supersonic aircraft and their engines to reach a more advanced stage, governments would derive more advantage from the application of results in the civilian field;
(2) by allowing the development of navigation facilities to reach a more advanced stage, the new facilities required by supersonic aircraft may be implemented gradually, thus distributing over a longer period the expenses involved;
(3) by permitting world air transport to reach a further stage of growth, the market for a supersonic airliner would be larger;
(4) holding off would permit the airlines to consolidate their economic position before embarking on substantial new re-equipment;
(5) by allowing the introduction of relatively low-operating-cost aircraft to replace present aircraft, the level of fares could be reduced;
(6) governments might decide that a supersonic airliner should not be introduced until it could be produced with vertical take-off and landing characteristics.

It is suggested that the start of work and the eventual introduction into service might be delayed by governments "for a number of reasons." The foregoing are the reasons that the authors have in mind. And in the preface there are the statements referred to in *Flight*'s preliminary review of the report the week before last. These are important enough to deserve repetition here:—

"The premature introduction of commercial supersonic aircraft could produce economic chaos in the aviation industry. . . . . The purpose of the [ICAO] Assembly in asking for this preliminary study on the effects of supersonic aircraft was mostly to exercise some sort of control over the time and manner in which the aircraft are to be introduced. The Council therefore *strongly* recommends that all governments co-operate internationally through ICAO . . . and *recommends* that within each State there should be co-ordinated action by all interested sectors of civil aviation."

**Supersonic specification** How does the ICAO study visualize the characteristics of the first supersonic airliners? If one were to be introduced at the earliest possible moment the speed selected would be Mach 2 to Mach 2.3. The main economic advantages of the Mach 2 type are that it would have lower operating costs, size for size and route for route. It would also be able to operate economically on medium stages, on which the Mach 3 aeroplane seems likely to be "extremely uneconomic." The Mach 2 airliner, having a lower output, would be produced in greater numbers, thus tending to reduce manufacturing costs.

Alternatively, a 150-seat Mach 2 airliner with the same output as a 100-seat Mach 3 airliner would have still lower seat-mile costs. If the Mach 2 machine could operate economically on medium as well as long stages it would first be used on both kinds of route; later the Mach 2 airliner could be operated only on the medium stages. Thus the argument that the Mach 3 aeroplane would rapidly render the Mach 2 obsolete might not necessarily be valid. *(continued on page 484)*

*Extract from "The Technical, Economic and Social Consequences of the Introduction into Commercial Service of Supersonic Aircraft, A Preliminary Study," ICAO Doc 8087-C/925, August 1960. HMSO, PO Box 569, London SE1. Price 8s 6d.*

**A Sunshine Finale for the 21st SBAC Display**

ILLUSTRATED MAINLY WITH "FLIGHT" PHOTOGRAPHS

# FARNBOROUGH WEEK

WITH the Society of British Aircraft Constructors' 21st flying display and exhibition finishing at Farnborough last weekend in a blaze of sunshine, there was an associated air of official optimism about similar occasions in succeeding years and about the future of the British aircraft industry. Sir George Dowty, the SBAC president, spoke on Sunday morning of the industry being "so full of work it can't find enough workers"—adding that he could see this situation continuing for the next two or three years. (The case of Short Brothers & Harland, whose SC.1 was the undoubted star of the 1960 show but who have been laying off workpeople, was said by SBAC officials to be a "special" one.) As to the future of these shows, the SBAC Council is to discuss whether to include overseas products incorporating British components; but an international exhibition on the lines of the Paris show was not contemplated.

Not only did the sun shine physically at Farnborough last week—the weather getting better and better from Wednesday onwards—but it also shone financially for several manufacturers of transport aircraft, orders totalling about £20m being announced. Most of these have already been mentioned separately; collectively, they are as follows: 5 D.H. Comet 4Cs and 16 AW.660s for RAF Transport Command; 6 Heralds for Jersey Airlines; 3 Avro 748s for BKS Air Transport; and "a substantial number" of Westland P.531/2 Mk 1 helicopters for the Army. In addition, Sir George Dowty let it be known on Sunday that Sir Roy Dobson had told him of a Greek order for 12 Avro 748s, together with a licence to manufacture; and during the week Rolls-Royce announced that the Tyne turboprop engine was to be built under licence in France, by Hispano Suiza, for the Breguet Atlantic and Transall C.160.

Attendances at this year's Show have continued an upward trend observable before 1959, when the long hot summer brought an artificial peak. There were 22,000 people at Farnborough last Friday, first of the three public days; then on Saturday the attendance climbed to 100,000, and on Sunday it climbed even more—as did the temperature (73°F). Because this final day was the biggest in point of crowds, and because it marked two notable last appearances, its highlights are described first.

**Sunday, September 11** What commentator Oliver Stewart described as a "technical conjuring trick of the first class" was performed for the last time at a Farnborough Show by that highly skilled conjuror from Belfast, Tom Brooke-Smith, in the SC.1; for when he climbed out at the end of an impeccable demonstration—translating from forward to vertical flight in front of the president's tent, like a well-bred racehorse being reined in—"Brookie" had concluded his test-flying career. His VTOL work has been an outstanding contribution to future developments, notably the Hawker P.1127 which is to be test-flown shortly.

The other final appearance at this year's Farnborough Show was made by the "Black Arrows" of Treble-One Sqn, giving their last performance there as the Royal Air Force aerobatic team. With blue skies and high cirrus cloud, they could not have had a more perfect setting; and their manœuvres showed how superbly they have developed the art of aerobatic flying by big formations, whether 18-strong for their initial Pterodactyl loop or in two teams of nine. Rightly, Oliver Stewart (when he came back on the air after the RAF commentator had finished describing the display) stressed that the skill and judgment needed for a stream landing by 18 Hunters was as great as that required in their airborne manœuvres.

On this final day, Valiants of No 148 Sqn did the V-bomber "scramble," four of them getting airborne in 1min 43sec—not so fast as the Vulcans had been on the Friday afternoon, but their own second-best performance. The sound of the Valiants' sixteen Avons all being opened up at once had been preceded by the

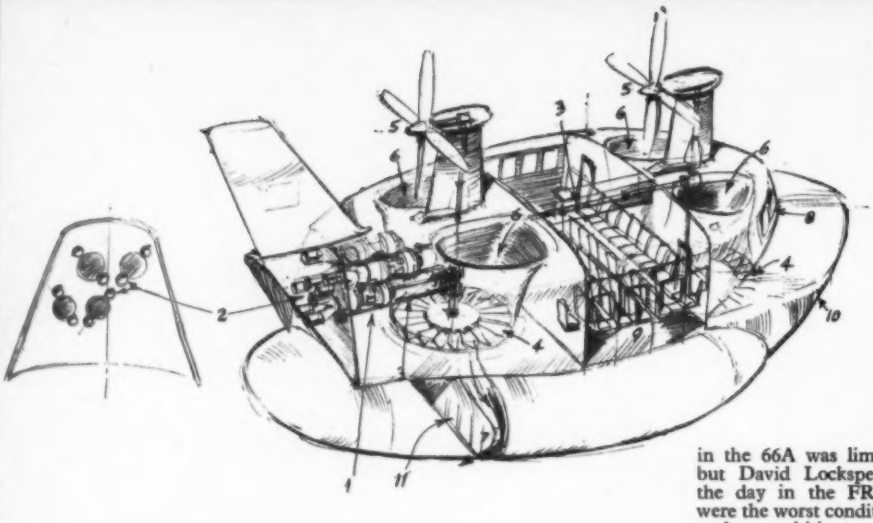
*Left, the ascent of the Vulcan B.2, stupendous in spectacle, stunning in sound*

*Right, the Hunters of Treble One run in, with smoke, before the bronzing, breathless crowd*

*An exclusive "Flight" photograph of five English Electric F.1s of 74 Squadron—the greatest number yet seen in an air-to-air picture. The squadron sent Lightnings over Farnborough on every day except one*

more gentle noise of an Auster and a Tiger Moth towing gliders, in a most pleasing display which the RAE Gliding Club arranged for the three public days. The pilots who performed these silent aerobatics were the club's CFI, David Martlew, in a Slingsby Swallow; the deputy CFI, Roy Procter, in an Elliott Olympia 2b; and the CFI and assistant CFI of the Lasham gliding centre, Derek Piggott and Brian Masters, flying respectively an Elliott 460 and a Slingsby Skylark 3. Towing was initially done by two Austers, one of them a 6a lent by the manufacturers; but after the other Auster met with an accident on its return to Lasham on Friday afternoon, resulting in the death of the pilot (Tony Thackery), towing was undertaken on the Saturday and today by the 6a flown by Derrick Goddard and a Tiger Moth flown by Leslie Creed.

[*Continued overleaf*



*Sketch by "Flight" artist Arthur Bowbeer of the Westland SR-N2 Hovercraft, a model of which was on display in the static exhibition. 1, paired engines; 2, exhausts; 3, shaft drive to 4 and 5; 4, fans; 5, propulsion and control propellers; 6, intakes to 4; 7, air-cushion duct; 8, control cabin; 9, passenger cabin; 10, spray barrier; 11, buoyancy chambers and fuel tanks*

**Farnborough Week . . .**

## THE TRADE DAYS

**Tuesday, September 6.** "Cloudy with intermittent slight rain. Moderate visibility." This understatement of the year was the official forecast on the morning of the first of the days on which the invited guests of the SBAC visited Farnborough. For "intermittent" read "continuous" and for "slight" read "substantial," and you have the weather actually experienced.

During the morning only the brave and well-protected were keen enough to stroll, or trot briskly, through the static aircraft park. Most visitors accepted the inevitable and stayed marooned in either the exhibition tent or the terraced enclosures, occasionally making a quick dash from one to the other.

Inside the big tent we had the choice of 300 stands, from the very smallest to the Big Two. On the Hawker Siddeley stand the products of member-companies seemed to be thoroughly integrated —that is, all mixed up—with Avro 748, Argosy, communications satellite and attendant salesmen cheek by jowl. In contrast, British Aircraft Corporation had divided its area neatly into quarters, placed a separate company in each, and co-ordinated the four with the central 10ft piece of sculptural symbolism.

A distinguished foreign visitor, with rain still dripping from his plastic mac, paused in front of the Ministry of Aviation stand and directed a long, enigmatic stare at the "rain gun." This, the caption told him, enabled windscreen wipers to be tested under the worst weather conditions in which they were expected to work, without actually having to wait for natural rain. This was accomplished by blowing over the windscreen a stream of air "with raindrops in it." Ah, these British and their sense of humour.

The flying display was opened at 2.30, in steady natural rain, with the Bomber Command scramble, this time by Vulcans of 617 Sqn. The first aircraft was moving after 40sec and in the air after 1min 10sec, and all four were airborne in 1min 47sec, nine seconds faster than the Valiants the previous day. In a slip of the tongue the RAF commentator mentioned the ability to get the force into the ground as quickly as possible, but we saw what he really meant.

Shackleton L-Lima of 201 Sqn, Coastal Command, touched down smoothly after its 22-hour flight which had begun at Farnborough during Monday's display. Regular turns at the controls had been taken by AVM L. W. C. Bower, AOC No 19 Group and Wg Cdr Alan C. Davies, squadron commander of 201. Their trip had taken them to Madeira, a point off Lisbon, out over the Atlantic where they had spoken by radio to a French weather ship, and back to the English channel for a routine training exercise. Area covered, approximately 80,000 square miles; distance flown, some 3,700 nautical miles; average height, between 800 (yes, *hundred*) and 1,000ft.

The display continued well, in spite of the appalling weather, with the S.C.1 blowing up clouds of spray from the runway as it hovered before and after its nippy circuit. Two newcomers were present today: the Westland Rotodyne and, making its first public appearance, the military Argosy 660. The latter flew over in two runs to display its wedge of a rear fuselage with door open and closed. On the debit side the Lightnings did not take part, the reason given (for the two individual aircraft) being the extremely wet runway.

For the 20 Hunters which took part the show was a triumph. Bill Bedford in the 66A was limited in what he could do by the weather, but David Lockspeiser obliged with the lowest fast run of the day in the FR.10. As for Treble One Squadron, these were the worst conditions in which the Black Hunters had essayed such an ambitious performance, and they excelled, tailoring their standard show to the wet and hazy visibility above Farnborough. In between the opening circuit (in place of the loop) and the final double loop, for which all 18 aircraft were together, the show was flown by the nine-man section led by squadron commander Peter Latham, with the second section of nine out of sight off stage. Referring to Treble One's Draken formation, the commentator informed us that it "does bear some resistance" to the Saab all-weather fighter.

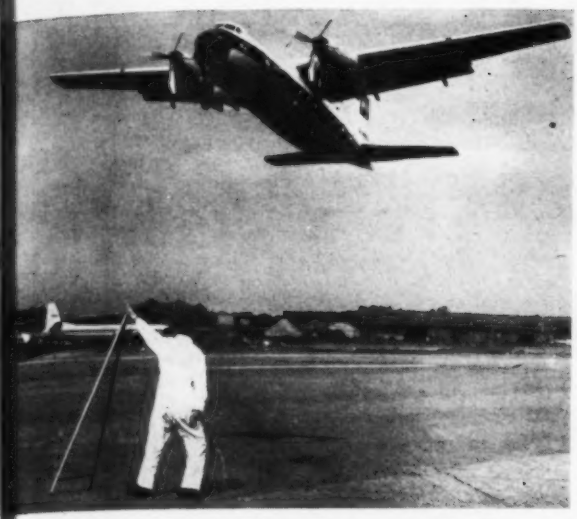
Among the day's visitors to the show were the Ministers of Aviation and of Defence, the Secretaries of State for Air and for War, Lord Mountbatten, Air Marshal Sir Thomas Pike and Admiral Sir Caspar John. United States guests included Mr E. R. Quesada, Administrator of the Federal Aviation Agency.

During the day orders were announced for six Handley Page Dart Heralds for Jersey Airlines; three Avro 748s for BKS; and "a substantial number" of Westland P.531 helicopters (the name Sprite was omitted from the announcement) for the Ministry of Aviation, for operation with the Army.

**Wednesday, September 7.** Although the atmosphere was decidedly damp, the rain held off throughout the day and the outdoor exhibits were able to receive their fair share of attention. The various missile demonstrations were most popular. On one site at the top of the big-tent hill the RAF showed a Bloodhound launch controller in action. "The launch controller presses the firing button . . ." the recorded commentary intoned, and the audience's eyes swivelled expectantly as one to the missile itself. But no, not this time.

A little way along from the RAF, the Army—and in particular D Troop of 60 Guided Weapons Battery, 36 Guided Weapons Regiment, Royal Artillery—was busy working on a Thunderbird. "Ssemmblerrmissile!" barked the sergeant, and the khaki-clad crew of five proceeded to 'ssemble the missile. "The men you see here," the elegant captain standing at the microphone informed us in impeccable Army-officer accents, "have become extremely fit and tough in their present work." They were the first unit to be equipped with the Thunderbird, he continued;

*Visitors to Farnborough on the Wednesday included (left and second from left) Dr Hans von Herwarth, West German ambassador; and Herr Franz Josef Strauss, West German Defence Minister. With them are Mr E. C. Bowyer, SBAC director; and (right) Mr H. N. Goodinge, deputy director*



*The Herald's under-600-yard departure over the tape*

**Farnborough Week . . .**

they had had the missile about one year and were going to fire it next month in Wales.

Meanwhile, what of the boys in Navy blue? All set to demonstrate a typical Seacat action sequence aboard a typical destroyer —typical, that is, except for the lounge-suited gentleman standing on the deck delivering an explanatory commentary through a portable loudhailer. "ALARM-AIRCRAFT-STARBOARD-LOOKOUT-BEARING-GREEN-FOURFIVE-ANGLERSIGHT-THREEFIVE" quoth the petty officer standing to attention by his side, whereupon controllers, missiles and launchers swung into action, tilting and swivelling with reckless abandon. "Having destroyed the targets," the loudhailer hailed with a lazy confidence, "there is a lull in the proceedings. . . ."

On our way down the hill again, we were almost knocked over by Sqn Ldr Peter Latham, piloting a motor-scooter through the tangle of jammed cars with the verve which one would expect from the leader of the world's best aerobatic team. At the foot of the hill our retreat was cut off by the Thunderbird-toting Army again, this time waving the missile around on the end of a Jumbo crane.

But missiles are not yet included in the flying display, and it was the Victors of XV Sqn which were the focus of attention at 2.30 p.m. Scramble time for the first aircraft airborne was 1min 27sec, and all four were away in 2min 8sec.

The programme unfolded as scheduled. Once again the agile helicopter circus mixed it up along the runway, with the Rotodyne retiring to its background circuit after a curtain-raising run. Once again the Vulcan B.2 seemed to hop into the air and then take a deep, level breath before climbing upstairs at its impossible angle. The Hunters were again superb, with Treble One in their full routine and Bill Bedford raising a vaporous eyebrow on his 66A in a low pass. But it was James Dell in the Lightning T.4 who shattered the runway-fringing crowd with the fastest, blastiest run of the day. Mach 0.95 was modestly quoted.

The West German Defence Minister, Herr Strauss; the US Secretary of the Air Force, Mr Dudley C. Sharp; and Soviet designers Oleg Antonov and Aleksandir Yakovlev were among the visitors to the show on Wednesday.

**Thursday, September 8.** A thick white morning mist gave a silent, ghostly atmosphere to the Farnborough scene. By 10.30, the forecast said, the mist would lift, and thereafter we should have a good day. This proved basically accurate, although optimistic in timing.

By now company representatives were becoming practised in answering visitors' questions and in dispensing information. In the aircraft park, literature on the Buccaneer was being handed-out by a bearded Blackburn engineer in loud blue overalls, while Vickers had entrusted this chore on the Vanguard to the two attractive TCA stewardesses who were aboard. The queue for the Vanguard was bigger than that for the Buccaneer.

As the mist cleared and the sun came out, the three figures on the tall Dexion tower in the equipment park were able at last to see the whole of the scene before them. It needed a second glance to realize that they were in fact dummies, illustrating the possibilities of the Britannia tail-servicing platform. Their continued stillness throughout the day gave an impression of a posed, offbeat photograph.

By noon it had become quite warm, and a host of exotic uniforms seemed to have blossomed in the sun. One smart blazer-badge turned out to be that of Strategic Air Command. Inside the exhibition tent the Ministry had another appropriate exhibit on view, this time concerning "thermal fatigue."

The Valiants of 148 Sqn, which had opened the first day's flying display on Monday, returned today to try to beat their scramble time of 1min 56sec. This they did in no mean fashion. The first aircraft took about the same time as on Monday to become airborne—1min 6sec—but the intervals were closed-up and the four were off the ground today in only 1min 37sec.

The display was in the best good-weather Farnborough tradition, with the Prospector wasting its cooling water-spray over the runway instead of over the enclosures, and the RAF's Hunters and Jet Provosts alike providing the best possible publicity for the Service. For good measure Bill Bedford gave us 15 turns of his smoke-trailed spin, while Keith Isherwood made his Farnborough debut on the Lightning F.1.

The major announcement at the show on this day was that Rolls-Royce and Hispano-Suiza had concluded a licence agreement for the joint production of Tyne turboprops.

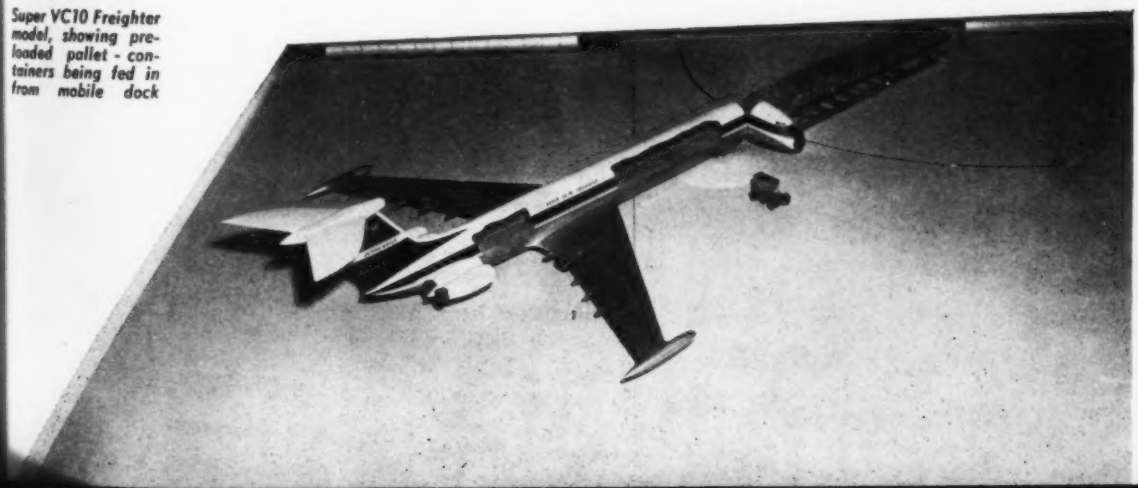
## THE PUBLIC DAYS

**Friday, September 9** It was rather like seeing famous actors in the wings, but this time in the changing room where pilots get ready for their demonstrations. (*Flight* can now reveal, on a sartorial note, that one famous test pilot gets into squash kit before putting on his g-suit.) In some cases, getting out to the aircraft involves a car ride; but we were lucky, because the four Jet Provost T.3s of the Central Flying School—hosts to *Flight* for the afternoon—were parked close to the control tower. At about ten to three we walked out to get settled in: the leader, Flt Lt Roy Langstaff (with passenger); Flt Lts Gerry Nicklin and Frank Brambley; and Plt Off Bruce McDonald. Plenty of time to do routine checks (while the SC.1 disported itself up and down the runway, on this fine clear afternoon) then taxi out at 1512 after the Twin Pioneer.

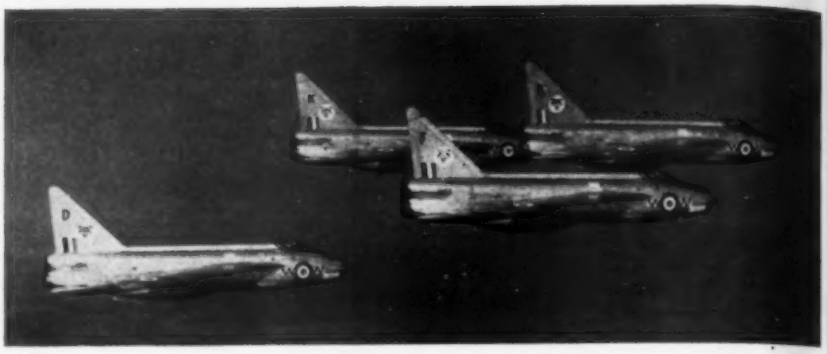
At 1519 we were off (I noticed Langstaff's left hand trembling, as he checked his watch just before opening up), with Brambley at No 2 tucked close in on the right and McDonald on the left, climbing westward until Odiham appeared under our nose. Cloud base was just above us, a layer of stratus at about 2,500ft. We turned starboard continuing through about 270°, then swung port for our run-in to the airfield. Still in box formation, we came in in a shallow dive to about 260kt, pulling up into a loop over the runway intersection. When we were just short of the inverted position, Langstaff called: "2, 3, go," and Brambley and McDonald pulled on ahead, the latter sliding into line behind Brambley in a scissors movement. At the same moment, Langstaff

(*continued on page 456, after double page of Farnborough photographs*)

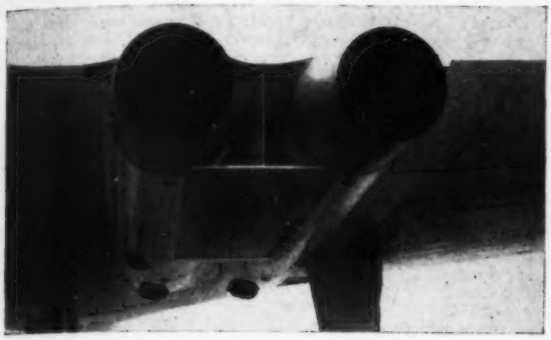
*Super VC10 Freighter model, showing pre-loaded pallet - containers being fed in from mobile dock*



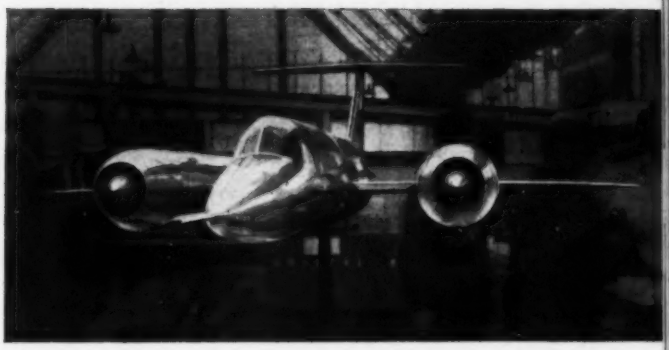
## Farnborough Week . . .



*These exclusive "Flight" photographs depict English Electric Lightning F.1s (two Rolls-Royce Avon) of No. 74 Squadron, Fighter Command, R.A.F. The formation made several runs over Farnborough*

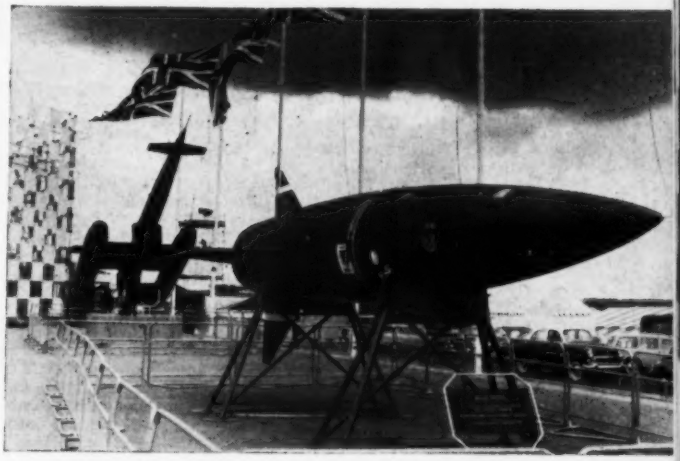


"Mystery" fitting on Vulcan B.2 (see page 413 last week)



Model of Bristol 188 (two Gyron Junior). Below, Avro Blue Steel

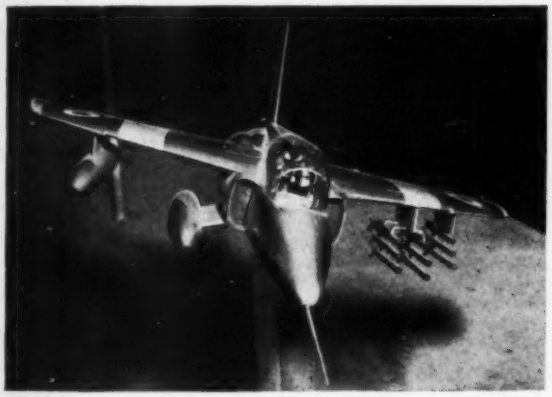
Short Tigercat battery on armoured fighting vehicle

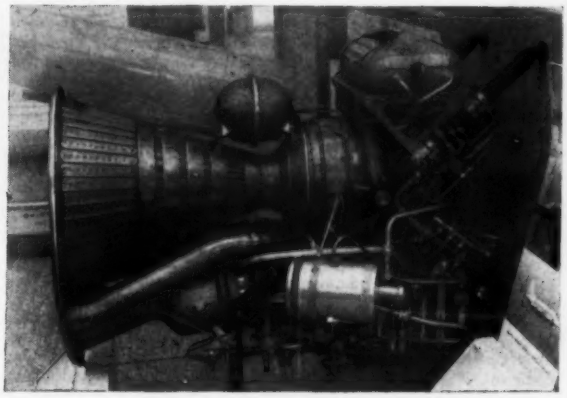


Short Tigercat battery on trailer with guidance radar on Land-Rover

Model of Gnat Trainer showing fuselage-mounted gun-pack

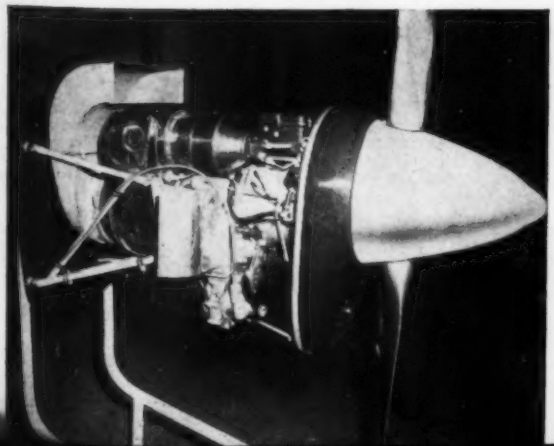
Bristol Siddeley Stentor

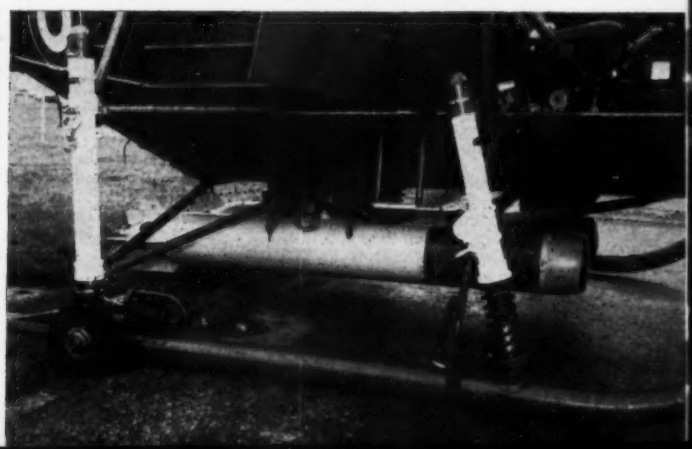


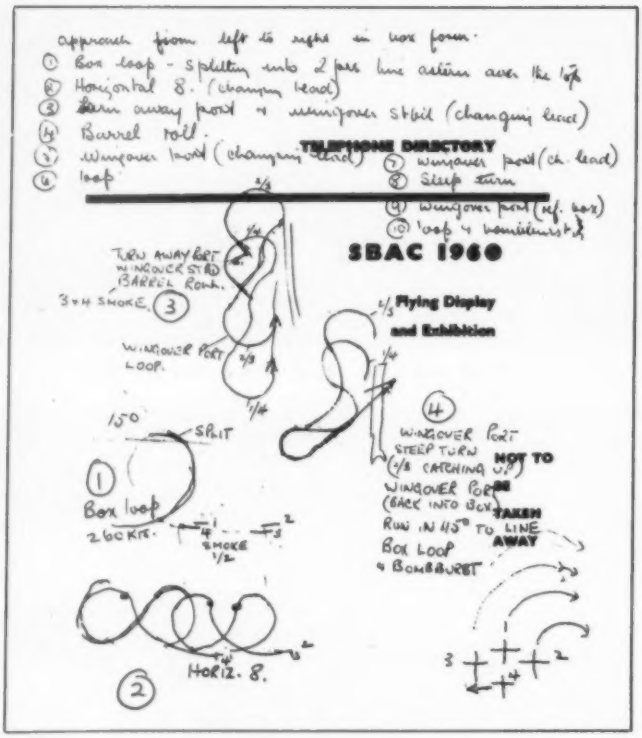


Rover TP.60 turboprop for light aircraft

Two homing torpedoes under Westland P.531 Mk 0






Approach from left to right in box form.
1 Box loop - splitting into 2 pass line astern over the left
2 Horizontal 8. (changing lead)
3 Turn away port & wingover stbd (changing lead)
4 Barrel roll.
5 Wingover stbd (changing lead)
6 Loop
TELEPHONE DIRECTORY
7 Wingover port (ch. lead)
8 Steep turn
9 Wingover port (ref. box)
10 Loop & bombburst
SBAC 1960
Flying Display and Exhibition
TURN AWAY PORT WINGOVER STBD BARREL ROLL
3+4 SMOKE
WINGOVER PORT LOOP.
150°
SPLIT
Box loop
2 LOCKS
SMOKE 1/2
WINGOVER PORT STEEP TURN (1/3 CATCHING UP)
WINGOVER PORT (BACK INTO BOX)
TAKEN AWAY
RUN IN 45° TO LINE
BOX LOOP & BOMBBURST
HORIZ. 8.

*Display routine described—on the internal telephone directory used in "Flight's" private enclosure during Farnborough week: text and diagrams by Flt Lt Roy Langstaff, leader of the CFS aerobatic team, whose brilliant sequence is herewith recounted at first-hand*

**Saturday, September 10** There is much to be said for watching the flying display from the opposite side of the airfield. Not only do the aircraft look different, but there is a sort of added dimension in the smells of smoke and exhaust gases. This was particularly so on this glorious sunny afternoon, for a steady breeze was blowing across the runway towards the control tower. When the 18 black Hunters of Treble-one Sqn taxied out it was impossible to stand near the perimeter track for the heat from their jet pipes being blown over the grass area to the north; and when they came down to the bottom of their first loop, before dividing into two teams of nine, the acrid smell of the smoke they trailed drifted across the airfield. Another acrid smell, of burning rubber, came from the Lightning T.4 when Wg Cdr Dell landed at the end of his demonstration and suffered failure of a Maxaret unit. He very skilfully managed to keep the aircraft straight and taxied off the runway, the port wheel being changed before the T.4 resumed its journey to dispersal.

Dell had earlier had to overshoot and was held off during the Treble-one aerobatic show, which ended appropriately just after the four Lightnings of No 74 Sqn (led by Sqn Ldr John Howe) made their final run. They appeared in a vic three with an odd man out, who justified his position by doing a series of upward rolls above his companions as they disappeared over Laffan's Plain. Immediately, Treble-one came over in their final loop; and the conjunction seemed to underline how much the display owes to the RAF for its spectacles. This year markedly so, for the V-bombers with their scramble (which was faster than ever today, with four Vulcans of No 617 Sqn getting off in 1min 24sec) and the Shackletons of No 201 Sqn returning from and departing for their all-night sorties have added an operational flavour; and the CFS Jet Provosts have shown that not all the skill in formation aerobatics belongs to Fighter Command. *Flight* could not resist another ride with these pilots of Flying Training Command, this time with Flt Lt Jerry Nicklin in the No 4 position. (In fact, each of the Jet Provosts carried a passenger, one being Bill Bedford on a busman's holiday.) Flying as the second in a pair gave an incomparably real impression of formation aerobatics, with the lead aircraft providing a mirror-like impression of one's own manœuvres. There was never more than a few feet between us, with a clear view of No 1's smoke canisters as they ignited in the first loop, and of his nosewheel doors fluttering open.

There was less cloud today than on Friday (at low level, after the Jet Provosts' bomb-burst, visibility was hazier) and a wide area of blue sky formed the perfect backcloth for Bill Bedford's phenomenal climb and spin in the Hunter 66A, charted by smoke. Yet there was enough moisture in the atmosphere to cause wingtip vortices by a Buccaneer on its similarly steep ascent. Good weather, moreover, remains the order of the day; at the close of his commentary Oliver Stewart forecast a "fine, sunny afternoon" for Sunday. As the Saturday crowd of 100,000 started on its homeward way, the Valiants from Marham began to arrive for Sunday's V-bomber scramble. No doubt this was not to the taste of the nuclear disarmament campaigners who had lined the road from Farnborough station with billboards carrying slogans; but Bomber Command has ably shown its operational alertness.

## Farnborough Week . . .

and Brambley pressed their switches to stream smoke. It was an exhilarating sight, from Langstaff's aircraft, to watch the other two Jet Provosts slide forward beneath us.

Immediately we pulled up into a horizontal eight with the other pair in parallel, the blue-and-white enclosures and black sheds appearing and disappearing beneath us. Then we turned away to port, following the turn with a wingover to starboard, playing follow-my-leader with Brambley and McDonald; then slowly over into a barrel roll, with Nos 3 and 4 starting to smoke (the canisters last just over two minutes); then a wingover to port, again changing the lead.

Next, up into a loop, followed by a wingover to port with the lead changing again; then a steep turn, with Brambley and McDonald coming up on our inside; another wingover to port, with McDonald tucking in on our left and Brambley on the right; a run-in at 45° to the line of the runway and up-up-up into a final loop, over the vertical, then—"Bomb-burst, go!"—and we were diving down across the airfield to the south, down low and fast across the trees of the Surrey countryside.

Langstaff checked his watch: we had six minutes in which to re-form to the east of the airfield and come in for a landing. As if drawn together by invisible strings, from the three points of the compass to which they had dispersed, the other three JPs slid up into box formation. As we came back towards the airfield, we could see the Prospector flown by Ken Rutter landing after his crop-spraying demonstration. Over the runway we broke in the order 2, 1, 3 and 4 and landed. When we shut down it was just twenty to three; we had been in the aircraft forty minutes. There was time to change and watch the rest of the display in comfort: the Javelin doing Derry turns; two Buccaneers in close formation, one of them later showing the Dayglo interior of its bomb-bay, then both landing from opposite directions; four Lightnings of No 74 Sqn; Treble-one Sqn, eighteen strong, then two impeccable patterns of nine; finally a Shackleton departing for its 22-hour NATO exercise.

Earlier, Tom Brooke-Smith had earned a round of applause for his performance in the SC.1, the Herald had flown 30 men of the 1st Parachute Regt Support Co, the Westland circus had given its impressive co-ordinated helicopter demonstration, the Victor and Vulcan had displayed their massive power output, and four Victors of No XV Sqn had scrambled in 1min 54sec. The afternoon had all begun very quietly, with a display of glider aerobatics mounted by the Royal Aircraft Establishment gliding club, and a parade down the runway of emergency vehicles—27 of them MoA-owned, three from the Hampshire Fire Service. Over all, the sun had shone, warm and unabatedly.

*After the ball: fascinating, and often fantastic, are the tyre-marks left on the RAE runway after the week's flying. Their interpretation—dimpled and treaded tyres, four-wheel bogies and a nosewheel with shimmy—is a story in itself. Sketch by "Flight" artist Frank Munger*

# Round the Stands

"Flight" photographs and copyright drawings

## ENGINES

LAST week, in the section "Highlights and Sidelights of the Static Show" we reported briefly upon present thinking in the propulsion of supersonic aircraft. Here it is appropriate to say something of the manner in which engines are being developed for the currently more important market of high-subsonic aeroplanes. It is generally conceded that the optimum engine is a ducted fan, or by-pass engine, or turbofan—and there are even other names for the same thing—with a cold/hot ratio of about unity (say Rolls-Royce) or at least 1.5 (say Bristol Siddeley and the Americans). It is probably too early to assess which group is nearer the truth, and telling arguments could be advanced on the Rolls-Royce and Bristol Siddeley stands in support of both.

We were able to publish an inboard profile of the new **Bristol Siddeley BS.75** last week, and there is no doubt that this is on paper a superb engine. Moreover, the direct application of experience with earlier gas turbines should ensure that it will also be good as hardware. As we noted on August 12, it has been sized to a fan flow of about 200lb/sec; cold/hot flow ratio is approximately 1.7, overall pressure ratio of the order of 14:1 and turbine entry no hotter than 1,200°K, so that design thrust comes out at 7,350lb. This was the optimum figure for the BAC-107 airliner, and the engine has now also been selected for the rival Avro 771. Both are twin-engined, so on this score Bristol Siddeley cannot hope to sell more than half as many engines as Rolls-Royce did with the Dart (assuming that one new jet will be bought to replace each Viscount). Moreover, it is unlikely that anybody will cut metal on a four-BS.75 airliner, since this would duplicate the Trident. On the other hand, a three-BS.75 project seems attractive, and this might well be a future Caravelle variant.

Returning to the school of unity by-pass ratios, the first item to fasten upon is the remarkable growth of the **Rolls-Royce Conway.** It is unfortunate that the roots of this great engine extend so far back into the past, since they have tended to hold back the Derby engineers in their quest for higher by-pass ratios. There is no point in denying that the ratio of the engines currently in service is below the optimum, at 0.3 (but this is better than the stark "zero" of its competitors). Freed from the confines of the Victor's wing, Rolls have since pushed ahead, and in the RCo.42 Mk 540 introduced a new low-pressure assembly giving a ratio of 0.6.

Now it seems clear that they have taken the bold step of producing an engine known as the Conway 7 by scaling their latest existing transport engine, the RB.163. The latter has a total mass flow only 2lb/sec greater than that of the BS.75, but owing to its lower flow ratio (1.0) gives ratings in the 10,000lb class. Scaling it up to a mass flow of 480lb/sec would produce an engine of around 24,000lb thrust, and it seems clear that this is what Rolls-Royce intend to do under the designation Conway 7—although they are not saying so openly.

To a considerable degree the huge cost of developing a new family of advanced engines in the 24,000lb class (and doubtless having growth potential up to about 30,000lb) will be minimized by the solid experience already gained with the earlier Conways, RB.141s and RB.163s; in fact almost everything learned about the 163 should read across directly to the big engine. Beyond the fact that the Stage-7 engine will start off with a guaranteed minimum rating of 24,000lb nothing has so far come out of the Derby citadel—but one very interesting conclusion can be gleaned from a study of Vickers' brochures on the Super VC10.

Whereas the original VC10 is being fitted with the RCo.42/2 of 20,250lb thrust, and the first series of "Supers" with the 22,500lb RCo.42/3, the heaviest versions so far envisaged will have the new Stage 7. In parenthesis after this statement Vickers insert the words "Allison AR.972-2." It has long been known that this division of General Motors are engaged in technical discussions with Rolls-Royce, and we have already published the fact that they would like to build a variant of the RB.163 known as the AR.963. It is not too much to deduce that engineers from Indianapolis are co-operating in the development of the most powerful commercial engine in the world, and that AR.972-2s may well one day flow from the plant at Indianapolis.

Switching to another topic entirely, it is worth commenting upon the outstandingly **long overhaul life** of several British engines. On August 22 the Dart 506s of TCA were cleared to run 3,000hr between overhauls—by far the greatest overhaul life of any aero engine. More than 12,000,000hr have been flown in airline service, and RR's stand contrasted the Dart 505 of 1953 (1,480 e.h.p.) with the Dart 542 of 1960 (3,030 e.h.p.). Close by, on the stand of the Smiths Group, were a pair of KLG KR.104 igniters, each of which had completed 2,500hr in Darts of BEA; this represents some 1,800 starts and at least 1hr 32min in full icing conditions. Back at RR one could see a commercial Avon 524, No 35088, pulled at 1,995hr and due to go back into a BOAC Comet for another 305hr. Finally, Bristol Siddeley displayed a Proteus 705, pulled from a BOAC Britannia on the completion of its authorized 2,400hr since last overhaul.

Indicative of the manner in which gas-turbine aerodynamicists can improve the performance of a given size of **axial compressor** were three examples of Gazelle compressors displayed by D. Napier & Son Ltd. The standard production engine has an eleven-stage spool known as the RA compressor; at 19,800 r.p.m. it achieves a pressure ratio of 6.2:1 with a mass flow of 16.6lb/sec while absorbing 2,280 h.p., and its efficiency of 87.5 per cent rises to an optimum value of 91 per cent at 87 per cent of the design speed—a typical cruise condition. At the research station at Liverpool work has led to the ten-stage RB compressor, which at the same rotational speed handles 20.9lb/sec with a pressure ratio of 7:1 while absorbing 3,170 h.p., the corresponding efficiency being 86 per cent. More remarkable is the Rig 2A high-pressure-ratio compressor, the fourteen stages of which achieve a pressure ratio of 11:1 at 18,250 r.p.m. while handling 17lb/sec with a power absorption of 3,500 h.p. and an efficiency of 84 per cent; at 10 per cent overspeed this compressor achieved a surge pressure ratio of 15:1, while absorbing 5,000 h.p. This suggests future Gazelles of over 2,000 h.p.

Perhaps the most fundamental part of any air-breathing engine is its **combustion system.** For many years the largest British company specializing in this field has been Joseph Lucas (Gas Turbine Equipment) Ltd, and this year three exhibits indicated current lines of research. The first, of a purely theoretical nature, was a small test chamber for the investigation of means whereby the maximum heat-release may be obtained per unit volume.

Of more immediate importance to existing engines is the company's work on equi-velocity sampling (EVS) and the achievement of optimum air distribution to the combustion chamber. This work has been directed at overcoming inperfections from variations in the velocity profile at the entry annulus to the combustion system. Since these variations are mainly across a radius, rather than around the periphery, air required for delivery to each sector is sampled from across the full depth of the annulus. This system is directly applicable to an annular chamber, but when separate flame tubes are employed Lucas have evolved an air-distribution unit (ADU) in which curved scoops pass full-depth samples alternately to the outside and inside radius of each flame tube to produce uniform air-delivery conditions upstream of the chamber.

**Round the Stands . . .**

# MISSILES and SPACECRAFT

ALL three British **anti-aircraft guided weapons** are continuously being improved, without losing the reliability which stems from years of development. Seaslug, for which the AWA/GEC/Sperry team were recently able to claim six hits out of six firings, appeared this year in production form with wing tips cropped at the trailing edge to reduce local heating during the boost phase, and with a repacked guidance receiver incorporating a great deal of printed wiring in the sub-units and interconnecting cable forms. Bloodhound, by Bristol Aircraft (airframe), Ferranti (guidance and control, launch control and test gear), AEI (Sting-Ray target-tracking and illuminating radar) and Bristol Siddeley (Thor ramjets) is in its Mk 2 form guided by CW (continuous-wave) radar and has new airborne guidance based upon printed circuitry and transistorization, and with inter-wire connections made by wrapped joints. Thunderbird, by English Electric Aviation, has also been developed with CW radar, and numerous small modifications improve its mobility and performance in adverse conditions.

All three missiles were on display with selected portions of their interior revealed for all to see. It is perhaps advisable briefly to outline the essential differences between the pulse form of radar employed in the guidance systems of Bloodhound Mk 1 and Thunderbird Mk 1 with the CW radars of the Mk 2 weapons (Seaslug is a beam-rider).

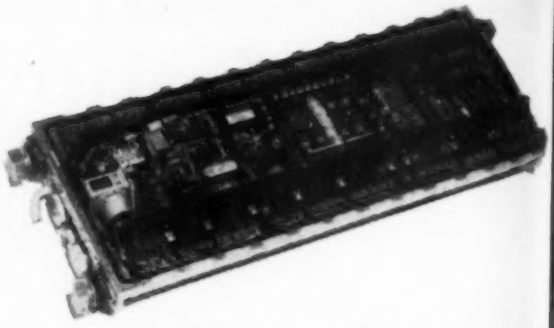
The pulse systems rely upon the transmission from the ground of a coded signal towards the target. The guidance receiver then has to wait for the signal to bounce off the target and return to the receiver dish aerial in the nose of the missile, whereupon the direction and timing of the reflected signal may be used in the determination of target range and bearing. It is, however, essential to endow the guidance system with the power of discriminating between spurious and real returns, so that it may accept, and home on to, only the true target signal. This must be unerringly locked on to, and all else must be rejected.

Since the time parameters can be measured to within about a microsecond, accuracy in range is excellent. But any modern bomber is capable of trying to play tricks with the oncoming missile, either by the brute-force method of jamming the guidance signal or by sending back false returns. The most direct way of foxing the system is to dispense "window," in any of a number of forms all designed to give an echo resembling as closely as possible that from the target itself. Even existing pulse systems can minimize this effect, but it nevertheless makes the task of interception much more difficult.

In a CW system the ground target-illuminating radar sends out a continuous emission, so that the missile receiver dish is always in receipt of a reflected signal. In order to produce a continuous signal on to which the missile can home it is essential to choose waveforms which can be processed and converted to steering information which can be fed to the missile control system. If the target knew enough about the missile guidance system it could distort these waveforms by altering their phase or shape, and so throw the missile off-course. To do this the target would have to have extraordinary intelligence.

Any window or chaff discharged from the target normally drifts with the wind, although it may be fired from a small rocket or decoy vehicle. Such countermeasures can be very effective in exactly the right place and at the right time, but normally a CW-homing missile can at once detect that the flight speed of the chaff or other countermeasure is not that of the real target. This discrimination in velocity overcomes the greatest foe of pulse systems.

The teams responsible for both Bloodhound Mk 2 (Bristol and Ferranti) and Thunderbird Mk 2 (English Electric Aviation) have been able to build on a vast background of experience with the pulse-guided Mk 1 weapons. In their approach to the problem of producing the Mk 2 systems they have been able to keep the entire field of ECM (electronic countermeasures) in the forefront of their minds. Both teams have taken into account all known methods of disrupting semi-active radar homing systems, and have done their best to ensure that the Mk 2 missiles will have an answer to all of them. Details of trials so far completed are naturally classified, but current experience is that all design goals will be met.



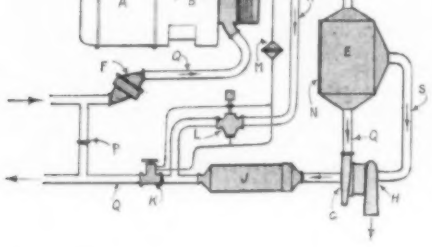
*In the dissertation on this page upon how Britain's anti-aircraft weapons are being made ever more lethal and reliable the emphasis is placed upon Bloodhound and Thunderbird. The Seaslug, in contrast, is a beam-riding missile, and its new GEC guidance equipment incorporates a great deal of printed circuitry, as this photograph shows*

Considerations of security still protect almost all portions of the **Thunderbird 2** weapon system, but certain facts can be stated and more can be deduced. The facts which can be stated are that the entire weapon system has been designed to be air-portable in current Transport Command aircraft, that the CW radar confers far greater lethality against hedge-hopping targets and much greater resistance to countermeasures, that the flight performance of the missile has been substantially increased and that engineering details have been generally cleaned up.

In external configuration Thunderbird 2 differs only slightly from its predecessor (the differences may not be elaborated upon). The launcher has been modified to achieve optimum compatibility with the CW guidance, and, of course, completely new ground radars are incorporated. Many portions of the weapon system are mounted not on prime movers as in the Mk 1 system but on pallets, trailers or units like railway containers. The total weight of the system is almost certainly less than that of the Mk 1.

English Electric Aviation were prevented from showing any Mk 2 hardware, but they were allowed to cut open a Thunderbird 1 more extensively than heretofore. This year the actuators for the four control fins were revealed, and seen to be conventional hydraulic devices. The solid-charge a.p.u. was fully sectioned, the warhead was replaced by a telemetry bay and the homing head was devoid of aerials and waveguides, had a spurious dish and the dish-actuation systems hidden from view. One could study the guidance electronics in detail and note the cunning packaging into discrete subassemblies for rapid servicing by replacement—a technique continued in the Mk 2 missile.

Development of the **Bloodhound** weapon system, including "directly associated" radars (which doubtless do not include the Metrovick strategic radar), has so far cost approximately £45m. It is noteworthy that Bloodhound has never been subject to criticism in the *Civil Appropriation Accounts* as have so many other British weapons. Examination of the cut-open Mk 1 missile was most rewarding in the guidance bay, which, as our drawing published last October 23 revealed, is divided into three 120° segments respectively occupied by the power supplies (with a hydraulically driven generator), a radar receiver (which processes the target signal into a form suitable for the third sector), and the electronic part of the control system (which transforms the signal into commands which work the homing dish and the missile wings). Reiterating what may be common knowledge, all semi-active homing missiles carry a radar aerial in the nose which receives a target signal (a coded radar transmission sent out from the ground and reflected from the target). This aerial is thereby automatically locked-on to the target, so that the latter is held exactly on the radar axis of the dish. The control system of the missile then tries to bring the body of the weapon into line with this axis and steers towards a collision point ahead of the target.

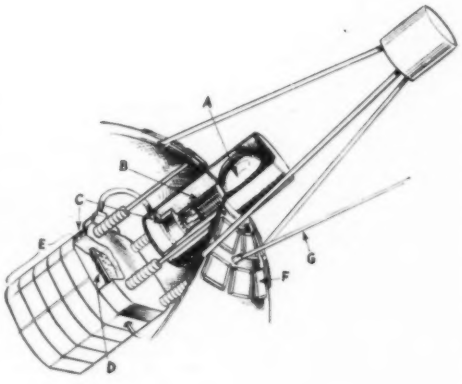



*In the text on page 459 the importance of the ground-conditioning of guided weapons is emphasized. The principle of operation of the Godfrey SCU-8 system can be clearly seen from this diagram (arrows at left show the flow to and from the missile): A, electric motor; B, gearbox; C, SRM compressor; D, venturi; E, heat exchanger; F, filter; G, brake turbine; H, compressor; J, water separator; K, sensing unit; L, control valve; M, ceramic filter; N, filter; P, orifice plate; Q, main return flow; R, by-pass flow; S, cooling air (a proportion of which may be dumped overboard, as shown)*

## Round the Stands . . .

All the electronics in Bloodhound 1 are arranged on printed-circuit boards which are paired to form units mounted radially within the guidance bay like blades on a paddle-wheel. Each twin-board unit is secured by four bolts, the wire connections to its neighbours being made by soldered joints on the outboard side. Following a malfunction, the complete 120° segment concerned would be removed by undoing eight bolts and pulling out a number of multi-pin plugs. When the faulty unit had been located it would be removed by breaking the soldered connections and undoing its four bolts.

In the case of Bloodhound Mk 2 each 120° segment is composed of a large number of printed-circuit boards arranged transversely. Each board is mounted in a cast aluminum-alloy frame with simple lugs mating with its neighbours. An individual unit may be pushed into place radially, all connections being made by parallel projecting wires inserted into corresponding holes on the inboard face of the bay. When in position the entire assembly is locked by being tightened up axially. Instead of subminiature valves Bloodhound 2 employs transistors, all components being mounted on the front of the board and the circuitry being etched on the back. Wire joints, also on the reverse face, are effected entirely by machine wrapping, which greatly reduces inspection time and simplifies the removal and replacement of individual guidance circuits.




*First genuine British space hardware is this cosmic-ray analyzer by McMichael Radio. To be launched by an American Scout vehicle, it will be carried inside a satellite shell supplied by NASA, which will also carry a number of other experiments, as described in the text (one of these is the cylinder mounted on the three struts): A, Cerenkov sphere; B, photomultiplier; C, electronic modules; D, printed-circuit boards; E, additional module packs (not yet allocated to McMichael); F, solar cells; G, whip aerial (one of many). This equipment is discussed overleaf*

The outstandingly reliable ballistic vehicle the Black Knight —original design by RAE, prime contractor Saunders-Roe Division of Westland and propulsion by Bristol Siddeley Gamma 201—has been put to a number of experimental functions, one of the most important of which is **re-entry.** Early single-stage firings were used to obtain data on a variety of patterns of re-entry vehicle, and one test nosecone configuration was exhibited by the Ministry of Aviation (then Ministry of Supply) at the 1959 SBAC Show after it had actually been fired at Woomera and recovered from ground impact.

Today much greater re-entry velocities have been reached by a new two-stage system which has an unusual configuration (see diagram). The test nosecone is mounted at the rear of an assembly which forms the second stage above a Black Knight booster. After separation of the latter the complete second stage continues to climb ballistically under its own momentum to an apogee of approximately 320 miles. Throughout this period its axis is maintained essentially perpendicular to the local Earth surface by the fact that the whole stage is rotated (like the first American satellite, fired from a rotating drum riding on a Jupiter C). The method by which the spin is engendered was not divulged by the Ministry, beyond the fact that it is of a pneumatic nature. The most likely arrangement is for air to be carried in a high-pressure bottle and discharged through jets or turbine buckets imparting a tangential impulse around the periphery of the unit 1 in the drawing overleaf.

This spin-stabilization ensures that as the vehicle falls from its apogee it does so tail-first. In fact, the tail, carrying the experimental re-entry vehicle, now becomes the nose, and the original nosecap is ejected. When the latter occurs, at an altitude of rather over 60 miles, the second-stage solid-propellant motor is fired and its thrust acts with gravity to produce an immense re-entry velocity (at least 15,000 m.p.h.).

When the second stage has burnt out the re-entry vehicle is separated by an arrangement of two explosive bolts and eight spring units (item 4 in the diagram). Final ground impact takes place roughly 60 miles from the launch point. Essential parameters are fully instrumented and recorded on tape throughout the flight.

Guided weapons contain a great deal of equipment which must either be kept at a **uniform temperature** or which generates heat which must be removed. During the pre-launch period of Bloodhound for example, the weapon is served by a cold-air duct produced by Avica Equipment as one of their Flexflyte range. A large-diameter hose in order to accommodate the great airflow specified, it is heavily wire-braided to provide protection against scuffing and heat blast when the boost motors are fired. An indication of how such a system works may be obtained from the diagram (at the foot of page 458) of the static cooling unit SCU-8 by Sir George Godfrey & Partners. The electric motor drives a Godfrey/SRM compressor energizing a simple air circuit involving a BT-3 brake turbine, the other units being as illustrated (the orifice plate matches air delivery to missile requirements). A related unit for aircraft application is described on page 465.

Apart from Blue Steel, described and illustrated last week, no guided weapon was on view "in the flesh" which had not been seen before. British Aircraft Corp, however, have been permitted to release the dimensions and external configuration of **Blue Water,** the "corps-support weapon" by English Electric Aviation's guided weapons division at Stevenage, Herts. Now regarded as one of the most important weapons in the British armoury, Blue Water has from the outset been planned to meet the requirement for a missile in this category stated by the Standing Group of NATO. It naturally meets these requirements perfectly, and has been accepted in principle by Britain and West Germany, two of the key member-nations; but it would be foolish to imagine that American industry will give up so large a market lightly, and BAC expect to meet bitter political opposition in their attempts to make Blue Water standard equipment from Norway to Turkey.

The new missile can be regarded as a replacement for Corporal (for which the Stevenage plant has for some years acted as foster-parent in Britain). As might be expected it is far smaller, the American weapon having a length of 46ft and body diameter of 30in, contrasted with Blue Water's overall length of 25ft and body diameter of 24in. Such reduced size is no indication of lower performance; in fact there seems no reason to doubt that the British weapon will have a much higher performance than its ten-year-old American predecessor. Nuclear warheads are now much lighter and smaller, inertial guidance systems can be produced weighing less than 200lb, and the choice of a solid-propellant motor of very high specific impulse slashes the propulsion weight —by far the biggest item.

Blue Water clearly employs no boost motor, but the solid-propellant propulsion system may well be divided into portions giving very high thrust for the launch phase and a lower thrust for the main duration of propelled flight. The motor appears to occupy the rearmost 10ft of the body, and the fact that as the charge is consumed there must be a considerable forwards shift in c.g. position is unlikely to have serious consequences. Around the motor nozzle is a boat tail and four fixed fins of parallel-double-wedge section. The control system appears to be mounted in the centrebody, from which protrudes a cruciform of moving wings indexed at 45° to the fins.

Following in the footsteps of the US Army's larger Pershing, these wings undoubtedly control the flight of the missile as it climbs upward through the atmosphere. Essentially Blue Water is a ballistic missile, but the four wings are necessary in order to ensure that it is established on the precise trajectory required. The American Sergeant has flight control by tail fins with trailing-edge control surfaces, and a number of weapons in this category employ gimballed chambers or jet-deflection (probably not used on Blue Water). The British missile body sections seem to be connected by rows of bolts. The nose is a pure ogive, with a pointed tip. The only photograph so far issued (last week's issue) depicts a black-and-blue Blue Water development round shortly after leaving the launcher. It suggests that the weapon is fired at an elevation which, although well over 45°, is not vertical. The possibility that the camera may have been deliberately tilted, or the print trimmed, cannot be overlooked, but it would seem reasonable to deduce that the launcher holds the weapon at any

## Round the Stands . . .

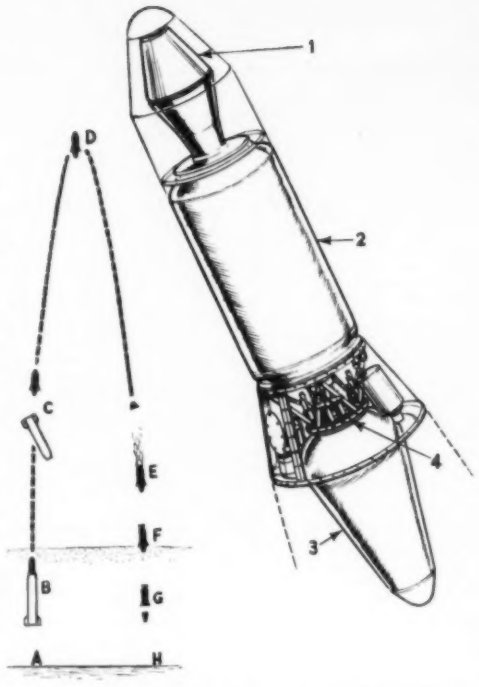
desired elevation and that the firing angle is normally of the order of 60°.

No details of Blue Water as a programme may be divulged, although the photograph already referred to shows that full-scale test vehicles have reached the flight stage. In April the London *Daily Mail* announced that the first missile had flown, although the venue was given as Woomera (Aberporth seems much more likely). Last week Herr Franz-Josef Strauss, West German Minister of Defence, discussed the missile with Mr Harold Watkinson, his British opposite number.

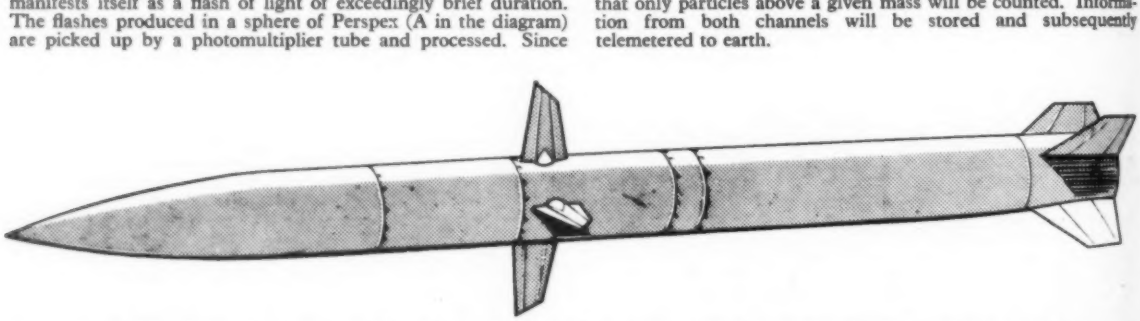
Although the point might well have been overlooked by most visitors, this year's SBAC show was the occasion for the first public exhibition of anything purporting to be a genuine example of British **space hardware** forming part of an active programme. Following discussions between the British and American Governments, several research groups in the UK are developing instruments which will be placed in orbit by American Scout rockets, beginning late next year. In our special issue on this subject on August 5 it was pointed out that the experiments to be carried out in Scout 1 (the first Anglo-American firing) are those recommended by the Royal Society's National Committee on Space Research.

Primarily Scout 1 will be an ionospheric vehicle, and its five experiments will all be for the investigation of the ionosphere or associated solar parameters. One of these experiments is being readied by Prof J. Sayers at the University of Birmingham and four are being prepared by Drs R. L. F. Boyd and A. P. Willmore of University College, London. A sixth experiment, under the supervision of Prof H. Elliot of Imperial College, is for the investigation of cosmic rays, and a model of the hardware was exhibited at Farnborough by McMichael Radio. Generally speaking, the American satellite will carry the British sensing equipment externally (for optimum sensing) and its electronics inside it in order to provide a more sanitary environment for the circuitry. The design of the equipment has yet to be frozen, but it will almost certainly be a sphere with a diameter of about 24in (sketch, page 459).

Basic geometry of the McMichael equipment can be seen clearly in the drawing. The apparatus consists of two separate experiments. One is a channel to measure general levels of radiation both inside and outside the van Allen belts, while the other utilizes a phenomenon known as the Cerenkov effect to count heavy cosmic particles. When the latter pass through transparent materials they may well exceed the speed at which light passes through the same substance, and the resulting "shockwave" effect manifests itself as a flash of light of exceedingly brief duration. The flashes produced in a sphere of Perspex (A in the diagram) are picked up by a photomultiplier tube and processed. Since the intensity of the flash is proportional to the square of the mass of the particle, elimination of pulses below a certain level ensures that only particles above a given mass will be counted. Information from both channels will be stored and subsequently telemetered to earth.




*These drawings, made from models displayed by the Ministry of Aviation, depict the design and method of operation of the re-entry test vehicle carried as a second stage on a Black Knight: 1, spin unit; 2, boost motor; 3, re-entry head under test; 4, separation unit; A, launch; B, first-stage all-burnt; C, first-stage separation; D, apogee; E, second-stage ignition; F, second-stage all-burnt; G, separation and re-entry of test vehicle; H, impact, about 60 miles from A*



*Last week we published the only photograph of Blue Water which has so far been cleared by the security authorities—a fuzzy shot of a firing trial. This drawing—specially prepared for us by English Electric Aviation—gives a much clearer indication of Blue Water's layout*

# ACCESSORY POWER

### Constant Speed Drives and Starters

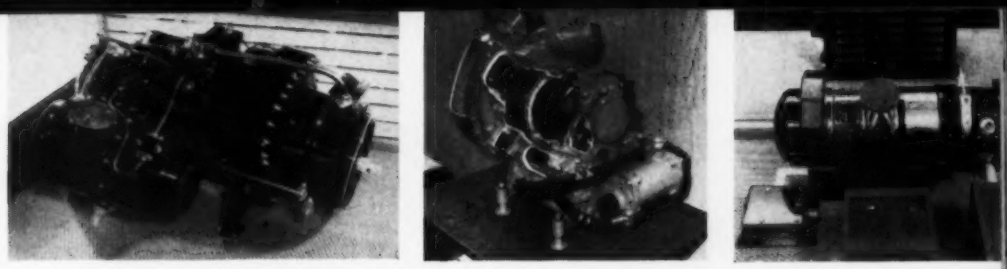
IN no previous year has such a variety of constant-speed drives appeared. Broadly, they are of two types: hydromechanical and pneumatic/mechanical, but an electro/mechanical unit and air turbine units are also available. In all cases steady-state control to within one per cent of nominal is offered and all are claimed to have a transient frequency response within five per cent with recovery in one second.

Past years have seen the appearance of the **English Electric**-manufactured hydromechanical Sundstrand drive and the new **H. M. Hobson** 30kVA unit which uses a double-differential gear in conjunction with hydrostatic power transmission. But the two pneumatic-mechanical drives which were shown this year by **Plessey** and **Rotax** are quite new, and attracted deserved attention. Plessey also showed the electro-mechanical drive developed by the French firm of Labinal and **Dowty/Rotol** an air turbine drive which is shortly to enter RAF service.

The Plessey unit is a constant-speed-drive starter, in which low pressure air from a remote source can be used for starting the engine or checking out the electrical system on the ground with the main power units stationary. A fundamental feature is the use of a Plessey positive-displacement air motor as the trimming medium for the differential gearbox. The Roots-blower type of air motor provides a "stiff" drive, so that as engine speed increases, air motor speed progressively decreases, until a point is reached where bleed air is required only in very small quantities to balance the static torque reaction of the alternator power load. At cruise point, the drive is at its most efficient (about 90 per cent) and air motor bearing speeds are very low. At speeds greater than cruising r.p.m. the air motor reverses and acts as a brake; no further bleed air supply is required.

The heart of the Plessey unit is the governor and hydraulic-servo air-control valve. The firm were perhaps fortunate in having available the fuel system governor used on the Perkins-built Solar

**Round the Stands . . .**



*Constant speed drives. Left to right Plessey CSDS, Dowty/Rotol air turbine and Plessey constant-speed alternator*

gas turbine; response is said to be very good under continual alternator load change and rapid engine acceleration. The arrangement is shown in the photograph; the alternator is co-axial, with an internal shaft passing through it to the gearbox. The remaining units are the air motor, air control valve, start control and overspeed shut-off valve and overspeed/underspeed unit. The CSDS has been very rapidly developed; a certain amount of external plumbing suggests possibilities for refinement.

Even newer than the unit just described is the Rotax CSDS, the first example of which arrived from the AiResearch division of the Garrett Corporation barely a week before the opening of the show. All the ground starting and check-out features are available and, should the primary power-supply source fail, bleed air from another engine can be switched to the unit so that it continues to operate on air alone. The pneumatic drive of the Rotax CSDS is by a well-proven air turbine and it is said that this arrangement reduces bulk for a given power output. Weight quoted for a 60kVA size is 55lb; for a 30kVA size 32lb, and a 20kVA size 30lb. To these must be added an allowance for the air control valve upstream of the turbine and for a small oil tank.

Because an air turbine drive is inherently "soft," and cannot be reversed, at the cruise point about 30 per cent of the total input to the alternator is supplied by the bleed air turbine. At this level the turbine remains highly sensitive to variation in the flow through the variable-area nozzle vanes which form part of the control system. For speed control the pneumatic governor—a centrifugally actuated spring-loaded poppet valve—supplies a signal to an hydraulic servomechanism governing the position of the nozzle vanes.

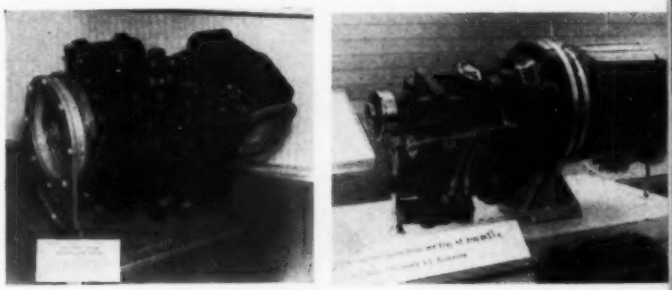
The Rotax CSDS is currently being tested at the Hemel Hempstead laboratories prior to full demonstrations; it could be in production and available in 12-15 months.

Since English Electric introduced the Sunstrand CSD some 500-600 units have been manufactured by the Bradford factory and overhaul life is now at least 800hr. The firm service 30kVA US units on BOAC's 707s and also supply others built in England. English Electric have considerable hope that they will supply 40kVA drives for the VC10.

A production flow of Hobson units for the D.H.121 suffered a setback when the aircraft was reduced in size and power rather over a year ago, and the 22½kVA drive matched to the RB.163 engines is still in the prototype stage. Following increasing BEA and D.H. confidence in the design when the 30kVA unit was run the earlier 30kVA 6,000 r.p.m. unit was extensively reworked in the reduction to 22½kVA. It now has an output r.p.m. of 8,000 with a consequent torque reduction by half. While development of the smaller drive has been proceeding alongside that of the engine and the airframe, the 30kVA drive has been used for development and components have reached 1,000hr "without performance deterioration." There are indications that initial overhaul life could be 2,000hr. Although Hobson were the first to propose using an alternator as a synchronous motor and starting the engine by changing the ratio of the CSD, this arrangement has not so far been adopted on the D.H.121 because of uncertainty about an a.p.u. But the facility has been kept in mind.

A second Plessey unit on show was the Labinal constant speed alternator. The constant speed unit here is an integral part of the rotor assembly and comprises an eddy current brake and differential gear train. Plessey have added a secondary input gearbox which raises the range of input speeds from 2,900-4,700 r.p.m. to 2,900-8,000 r.p.m.

Solely air turbine drive is used in the Dowty/Rotol 15kVA design and speed control is achieved through a governor and AiResearch-type variable-area nozzles. The turbine and alternator rotate at 24,000 r.p.m., but the unit is lightweight and weighs 112lb complete with its integrated electrical machine. Transient response is ±3 per cent for a 50 per cent load change. The



*Hobson hydrostatic drive (left) and English Electric Sundstrand*

advantage of this type of drive is that it can be positioned anywhere that an air duct can be led and cross-bleeding is simple, but of course large amounts of bleed air are required.

**Electrical Generators**

PLENTY of a.c. brushless generators are now being manufactured in Great Britain, the only country on this side of the Atlantic to have such units in operation. Newest of all is the **Rotax** solid-rotor type, 15, 20 and 30-35kVA sizes of which were on show. These machines are designed to replace salient pole types and although power/weight ratios are not so good, lack of centrifugal force on the insulation of wound poles allows a better material to be chosen. Higher temperature operation is thus possible.

For the VC10, brushless 40kVA alternators are being supplied by **Plessey.** These are of Westinghouse design built under licence, as are the 30kVA units supplied to BOAC for the 707. Following bearing changes the latter has in prospect an overhaul life of 3,000hr. Another manufacturer of brushless machines is **English Electric,** whose 50kVA units are either air or, now, oil-cooled. The latter will be used on the Victor B.2, and oil-cooled units are expected to supersede air-cooled designs on military aircraft. Air-cooled 50kVA units weigh 87lb, oil-cooled units, 103lb. The same firm are producing 9kW d.c. generators for Dart-engined aircraft and have received inquiries for these from the US. The speed range is 5,000 to 10,000 r.p.m. but on a limited speed range the rating can be increased to 12kW.

Alternators for the D.H.121 are being developed by AEI although no examples of the 22½kVA size were on show. The 40kVA unit demonstrated is, in fact, similar to the 22½kVA machine except in size and output r.p.m.—raised from 6,000 to 8,000. The latter weighs 55lb, is cooled by ram air and is lubricated by oil circulated from the engine. A unit on test at Coventry will shortly be passed to de Havilland for rig testing and a further two units are in use by H. M. Hobson on the associated CSD.

**Pneumatics** Particularly intriguing pneumatic actuators have been developed by Rotax and by Plessey. The former is a linear or rotary actuator and, as the sketch shows, is a cam-piston design (from AiResearch) utilizing bleed air as a direct energy source. No "conventional lubrication" or artificial cooling is required. Power output of the rotary actuator is 7.8 h.p. and the linear actuator has a stall load of 2,500lb.

Plessey's twin air-motor unit is associated with efflux control of a Bristol-Siddeley engine. The input lever acts as the displacement control of a shaft which can rotate in either direction through a selected number of degrees. Output torque is 200lb/hr at 100 r.p.m. but the essence of the design is a fast response rate and full proportional feedback to give stiffness. Duplication of

(*continued on page 464*)

**CONSTANT-SPEED DRIVES**

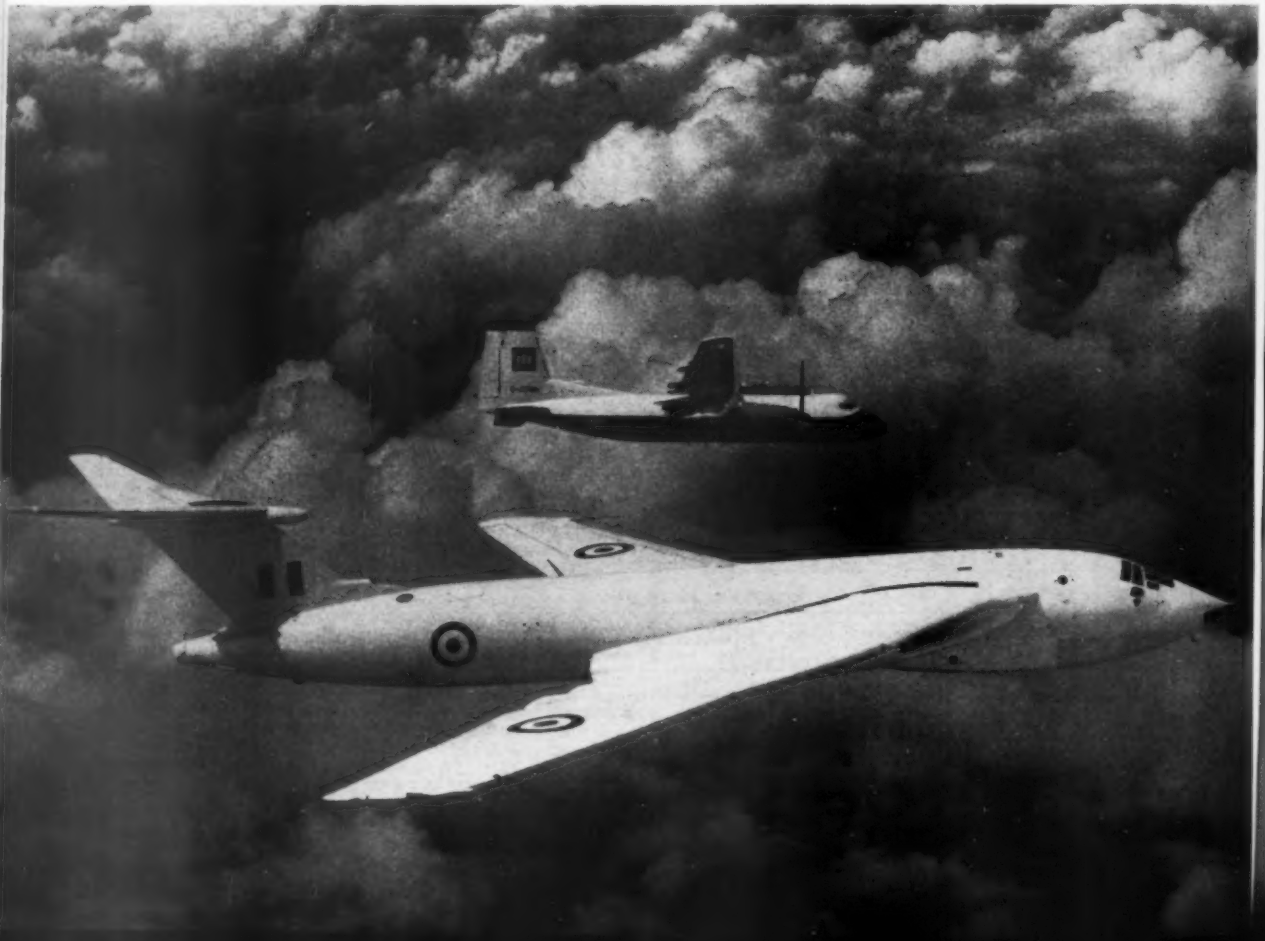
| Manufacturer | Type | Nominal size | Output r.p.m. | Frequency control (per cent) | Starter capability | Full ground check-out capability | Oil system | Remarks |
|---|---|---|---|---|---|---|---|---|
| Dowty/Rotol | Bleed air only | 15kVA | 24,000 | < ±2.0 | No | Possible | — | Weighs 112lb with alternator |
| English Electric | Hydromechanical | 40kVA | 6,000 | ±0.5 | No provision | No | Separate | For VC10 |
| Hobson | Hydromechanical | 22½kVA | 8,000 | < ±1.0 | †No provision | No | Integral | Max hydraulic transmission 15 per cent. (For D.H.121) |
| Plessey | Mechanical + air motor | 40-50kVA | 8,000 | < ±1.0 | Air | Yes | Integral | No bleed air at cruise and above |
| Plessey (Labinal) | Electromechanical | 4-15kVA | 2,900-8,000 | ±1.0 | No provision | No | — | |
| Rotax | Mechanical + air turbine | 20-60kVA | 6 or 8,000 | ±1.0* | Air | Yes | Separate | Cross-bleed operation possible |

*May be < ±0.25 per cent with special fine control. †Hobson are associated with AEI in the development of starting system using alternator as synchronous motor

*Left, CFS Hunting Jet Provost T.3s. Above, Bill Bedford spinning the Hunter 66A*

# SMOKE AND CUMULUS

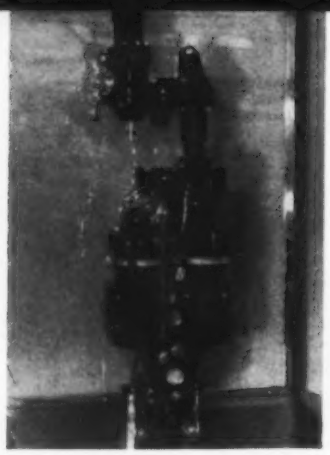
*Heralding the Victor: Handley Page's twin-Dart feederliner in attendance upon the mighty Victor B.2 strategic bomber (four Rolls-Royce Conway*



# HEAVY LIFT IN TWO VERSIONS

*Above, the second of 23 Vickers Vanguards for Trans-Canada Airlines. Below, Westland Westminster now with a tailplane*

## Round the Stands . . .

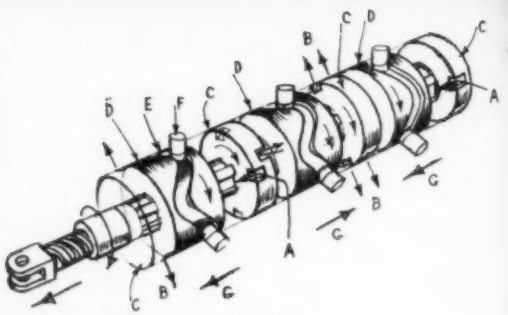


*Plessey twin air-motor servo*

the air motors is provided to protect against any possible seizure; the outputs are differently coupled. Air motor rams with re-circulating ball actuators are another Plessey product.

**Hydraulics** An impressive display by **Lockheed Precision Products** was a reminder that over 70 hydraulic components are to be supplied by this firm for the D.H.121—the nose undercarriage, selector valves, retraction jacks, sequence valves, accumulators, fluid couplings and filters. All will operate on Skydrol. Seal housing development over many years has given Lockheed an insight into good design for long life and one internal and one external seal is now always used on seals between pressure and atmosphere. This firm have also developed a hydraulic filter, the bowl of which cuts off the hydraulic lines by means of spring-loaded drop-down valves when it is removed and the first nose undercarriage leg is now on test at de Havilland.

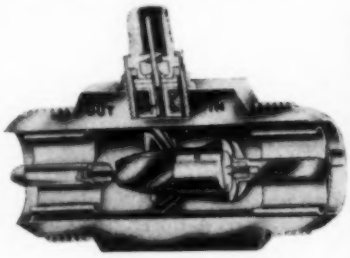
A final new item of hydraulic equipment is the **Joseph Lucas** flow control transducer, a product of Hydraulic Research of Burbank, California. It has been developed for control of flows between 0.15 and 15gal/min at pressures between 150 and 4,000lb/sq in. The flow gain linearity is ±5 per cent.




*Rotax pneumatic actuator. A inlet ports, B exhaust ports, C rotating valves, D rotating pistons, E cam track, F earthed cam follower, G direction of piston at this point of sequence*

*Right, Hobson fuel booster pump*

*Below, de Havilland Pottermeter*



## FUEL SYSTEM EQUIPMENT

FUEL system equipment has undergone steady development during the last year, but there is very little that is totally new in concept. Simplification of fuel system management in modern aircraft has accentuated the development of fuel flow proportioners and there are a number of these on show.

**H. M. Hobson** show their range of twin-cell, positive-displacement proportioners which utilize cycloidal rotors as proportioning elements. They can either be unpowered (the proportioning elements being driven by the fuel) or they can be powered by a gear type air motor, thus providing an increase in fuel pressure. On show was a 1,000gal/hr unit developed for the D.H.121. A feature is that an automatic by-pass is provided in parallel with each proportioning cell to cater for a seized rotor condition. The **Dowty Group** show a four-tank proportioner with a single outlet connection which has been developed for strike aircraft.

Because of the wide power range of present-day gas turbine engines, fuel tank booster pumps have to cater for a variety of flow and pressure combinations. This is exemplified on the **S.P.E.** stand where pumps capable of handling fuel at rates up to 4,000gal/hr are on show. Power is provided by DC or AC electrical motors, air driven turbine, or hydraulic motor. Another hydraulic powered pump has been developed by **Lucas (GTE)**. Hobson show a pump which has been specified for the D.H.121. This has a fuel-immersed AC electric motor. The canister in which the pump is mounted incorporates a rotary valve to enable the pump to be changed without draining the fuel tank.

Serious accidents have occurred in the past because non-return valves have been installed in fuel lines incorrectly. **Flight Refuelling** have produced a range of "anti-Murphy's Law" NRVs which are irreversible and so overcome this hazard. This firm shows its latest fuelling valve which may be tank or line mounted and is suitable for refuelling or defuelling. It is solenoid operated, has surge relief and gives an electrical indication as to whether it is open or closed. It is capable of handling flows up to 240gal/min and has a manual override for defuelling without electrical power.

The number of fuel flowmeter manufacturers has been increased this year by the entry of **D.H. Propellers** into this field. The D.H. flowmeter, which is an impeller type, is based on the US Potter design and will measure mass or volume. The rotor of the Pottermeter, as it is known, has no bearings and is positioned hydraulically. **Elliott Brothers** show their flowmeter which has been developed for the VC10. The transmitter senses the true mass flow of the fuel and produces an electrical signal proportional to the flow rate. The signal is passed to a computer which is designed for aircraft radio equipment air-cooled rack mounting. There are two outputs from the computer; one feeds a rate-of-flow indicator and the other a fuel-consumed counter, both of which are contained in a single indicator case.

In an endeavour to reduce the size and weight of components, **Smiths Aircraft Instruments** have developed their Type 4 transistorized fuel contents gauge. Detailed design of the tank probes has been improved and the amplifiers and indicators can be supplied either as separate or combined units in standard case sizes from 2in diameter upwards. A range of sub-miniature co-axial connectors has been developed for the tank wiring, and equipment has been produced to enable the operator accurately to preselect and control refuelling and defuelling operations during ground handling of the aircraft.

The increased use of the gas turbine engine in civil aircraft has highlighted the need for clean fuel. The contamination level of fuel has always been extremely difficult to determine, but **Thermal Control Co** have introduced their Millipore sampling set. This consists of a monitor unit which contains a Millipore filter membrane which has a cut-off size of approximately 1 micron. A measured representative sample of the fuel to be analysed is passed through the filter membrane which retains on its surface contaminant present in the sample. The membrane is then removed and can be subjected to microscopic counting, sizing and identifying of the contaminant particles. Alternatively, if previously weighed, it may be dried and reweighed for a gravimetrical analysis.

Engine fuel systems and components are shown by Lucas, and Dowty and Hobson are working on reheat systems for the D.H. Gyron Junior engine.

*Armstrong Whitworth Equipment fuel system display*

**Round the Stands . . .**

# AIR CONDITIONING

AS seen at Farnborough this year, news in air-conditioning equipment was centred principally on means of cooling, on pressure control, on quieter recirculation fans, and on emergency oxygen supplies.

In the cabin-refrigeration field, development continues on both air-cycle and vapour-cycle systems, and combined air and vapour cycles are coming in—for instance, on the Britannic freight transport for the RAF, although such systems are not yet in evidence. A new small, compact vapour-cycle refrigerator intended for helicopter cabin cooling was shown by **Normalair**. Weighing 14lb, it is an electrically-driven twin-cylinder reciprocating compressor operating with a refrigerant such as Freon or Arcton. On the same drive-shaft is mounted a fan which draws in cooling air to the refrigerant condenser.

Cooling of electronic equipment is as vital to the operation of a modern military aircraft as keeping the crew comfortable. A complete vapour-cycle pack, using Arcton II, for equipment cooling on a V-bomber was the principal exhibit on the stand of **Sir George Godfrey & Partners.** The pack, which weighs about 120lb, comprises a sealed 8 h.p. motor-driven screw-type (SRM) compressor, a vapour/oil separator, a condenser, filter and dryer, manual shut-off valve, expansion valve and evaporator, together with the evaporator temperature control system. The aircraft equipment—which is remote from the pack—is cooled by a water/glycol coolant which itself is cooled by circulating through the cooling pack evaporator, at a controlled temperature of 55°C.

A somewhat specialized interpretation of "air conditioning," in the form of a miniature air liquefier, was shown by **Hymatic.** This equipment was developed for cooling missile-system semiconductors to liquid-air temperature (−194°C) and thereby increasing their sensitivity. The air liquefier utilizes the Joule-Thomson effect in conjunction with a regenerative heat exchanger; air initially at 3,000lb/sq in is expanded through a 0.0012in diameter nozzle.

Technically one of the most interesting pieces of air-conditioning equipment seen at Farnborough this year was the Sixsmith miniature expansion turbine, less than 3in long and capable of expanding 50 cu ft of free air per minute from an inlet pressure of 90lb/sq in and an inlet temperature of 120°K. The turbine, designed as a cooling unit for air-liquefaction apparatus, is now under development by **British Oxygen Research and Development,** and units built on this principle are thought to have interesting and widespread possibilities as cold-air units for aircraft air-conditioning systems. The outstanding feature of this little turbine is the use of hydrostatic air-bearings, which make possible an operating speed of 500,000 r.p.m.—and, consequently substantial reductions in size and weight.

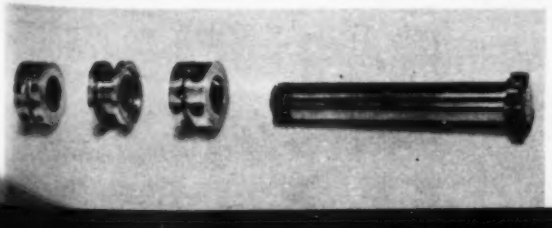
While visiting the **British Oxygen** stand, we learnt that interest in liquid-oxygen breathing systems is increasing, not only for military aircraft, but also for high-flying commercial jet airliners. Today the latter are required to provide emergency oxygen supplies for passengers as well as crew to guard against failure of the normal air-conditioning system at altitude. This observation was confirmed at the stand of **Normalair Ltd,** who had on view the 30-litre lox converter that they have developed for the Vickers-Armstrongs VC10 (which probably will be the first commercial aircraft equipped with a lox system). On an aircraft with the range and passenger capacity of the VC10, the use of a single compact liquid-oxygen converter can offer very appreciable savings in weight and space over gaseous-oxygen bottles.

The Normalair lox converter developed for civil applications is the first to incorporate the essential feature that there is always a reserve supply for the crew sufficient to complete the flight, whatever the demands made by the passengers. This is achieved by providing separate supply lines for passengers and crew, with pressure-operated valves so arranged that, after the liquid level falls below reserve level, the passengers' supply line is shut off; but it is still possible, at the discretion of the crew, to re-establish the supply to the passengers by linking the two supply lines through a transfer valve. The VC10 passenger emergency system fed by the lox converter will be of the automatic presentation type, and is now under development by the **Walter Kidde Co.**

Although none of the actual components were on view, Normalair were also illustrating the new electro-pneumatic pressure control scheme that they have developed for the VC10 air-conditioning system, in which the discharge valves are pneumatically operated in response to electrical signals generated by a control unit which senses cabin altitude, rate of pressure change and differential pressure, and relates them to values selected by the crew. This control system provides a simple lightweight installation with the high response speed of an electronic system combined with the safety of the well-proved pneumatically operated discharge valve.

Noise arising from recirculating cabin air has, since the advent of quiet turbine engines, often been unpleasantly obtrusive in the cabin. **Plannair** have been doing a lot of work to overcome this nuisance, and now offer built-in sound mufflers on their latest axial-flow fans. Two such fans, both designed for the VC10, were on view at Farnborough. One of these, the cabin air recirculation fan, has a capacity of 700-1,100 cu ft/min, and is driven by a 6 h.p. motor. The other, a 580-750 cu ft/min fan designed for radio-rack cooling and/or louvre boost, incorporates a double-circuit centrifugal switch for contactor operation. Also seen on the Plannair stand was a portable fan heater designed for the Shell group's executive Ambassadors (recently converted by Field Aviation Services Ltd), for heating or cooling the aircraft on the ground, by means of a 6kW heater with a 200 cu ft/min air blower.

***Components of British Oxygen's miniature expansion turbine, of potential use as a cold-air unit. Bearings are air-lubricated***



# PERSONAL AND RESCUE EQUIPMENT

***Martin-Baker Mk GQ-5 ejection seat***

THE well-dressed aviator is wearing lighter and more comfortable gear this year, if one is to judge by the many exhibits under the heading "personal equipment" which were in the main hall. At the same time, survival and rescue are becoming ever more precise sc.ences.

Masters of the quick getaway, **Martin-Baker,** on a stand of the utmost simplicity, showed one of their latest seats, the Mk GQ-5, designed to fit the F-104G Starfighters being supplied to Dutch, Belgian and German air forces. This has all the features of the latest RAF ground-level ejection seats, with an 80ft/sec gun, but needed redesigning to fit the ejection angle of the Starfighter, which is only 12° off the vertical, instead of the standard British angle of 25°. Britain's only other ejection-seat maker, **Folland Aircraft,** showed their lightweight Mk 4 ejection seat, now cleared for the whole flight envelope of the Gnat Trainer, and for runway ejections at speeds down to 90kt.

**Airmed** and **Amplivox** both showed a bewildering range of headsets, microphones and oxygen masks. Both of these companies have devoted much thought to making these equipments lighter and more comfortable. We particularly liked Amplivox's "featherweight" headset for private pilots and air traffic controllers. Complete with clear plastic ear-shells and boom microphone, this weighs only 3oz. The same company's Amplilite headset comes in several different forms—a new one for tropical use has ventilated ear-shells.

Airmed showed the new SP-4 civil oxygen mask, with chain toggle, designed for very quick donning. The company markets a small attachment for suspending an oxygen mask from a standard airline cap, but for the majority of airline pilots who fly bare-headed there is an infinitely variable headband for mounting a mask. Both companies showed boom microphones for attachment direct to protective helmets, designed for "low-altitude" pilots (e.g., of military helicopters and agricultural aircraft) who want a bone-dome but no mask.

The Navy's helicopter pilots will probably be chief users of the latest version of **R.F.D.'s** single-seat dinghy, the Mark 5, which is now worn around the body rather than as a separate pack. This aids escape from ditched aircraft, particularly helicopters, where dinghy packs have proved a hindrance to escape in the past. R.F.D. are now working on a type of single-seat dinghy which will inflate beneath its wearer, and lift him from the water. Recent improvements installed on the 26-seat liferaft, the basic survival apparatus of a host of airlines, are an air-entraining venturi inflator, which reduces the amount of bottled gas which need be carried, and an inflated boarding ramp which makes it easier to crawl aboard the raft. Droppable ten-seat liferaft pods have been developed for helicopters. One can be installed on either side of the Westland Belvedere. R.F.D. are now in production with both British and American pattern twin compartment lifejackets. The British design jacket will support a fully unconscious person when either chamber is deflated.

**Burndept** and **Ultra** both showed miniature rescue beacons. Burndept now produce the Sarbe beacon, without speech facility, for the RAF. This broadcasts on the UHF distress frequency, 243Mc/s. Ultra now fit their standard RAF Sarah beacon with a transistor power supply convertor, so that both low- and high-tension currents can be drawn from one 6V dry battery. Sarah has been adapted for use as a recovery beacon for camera pods and similar devices.

Twin-cell lifejackets are becoming more common, and for them **Walter Kidde** manufactures a twin inflator. This company showed two types of automatic inflator, one using a soluble plug and the other compressed synthetic sponge which swells in water. This latter type is used on **P. Frankenstein's** auto-inflated lifejackets and liferafts, which are currently undergoing trials. Also displayed on the Frankenstein stand was its latest anti-g suit, the Mk 6, and a model of a "rigid foam house." With Arctic rescue or exploration potentialities, this latter consists of a light proofed-fabric envelope, blown up by a low-pressure compressor. From the inside it is then sprayed with polyurethane, which foams and sets almost instantly as a rigid and insulating material. The houses can be parachuted as complete construction kits. A building of this type is likely to be tested in the Himalayas next year.

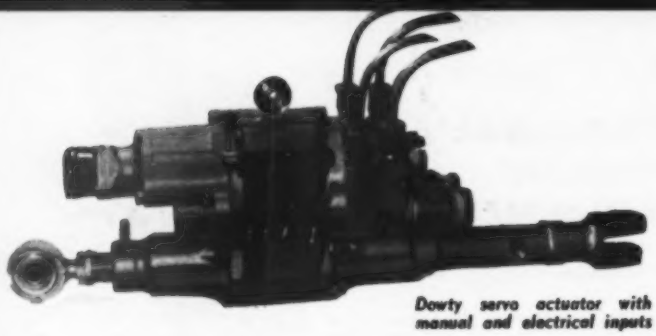
**Baxter, Woodhouse & Taylor** displayed the Taylor partial-pressure helmet, which the company claim is the only helmet of its type adopted by the RAF. Weighing 5lb 14oz, the helmet closes immediately when a drop in pressure occurs.

Liquid-oxygen systems are now contemplated for several transport aircraft, for both the crews' emergency supplies and the relief of passengers who find even normal pressurization rather thin. **British Oxygen** and **Normalair** both showed examples (see column one)—Normalair a 30-litre convertor for the Vickers VC10, and a new type of oxygen demand regulator, while British Oxygen showed a convertor for the Gnat Trainer, of 3.5 litres capacity. Transport aircraft for which this company is now developing oxygen systems are the AW.660 military Argosy, which will have one 25-litre convertor, and the Short Britannic, which will normally have two of the same size.

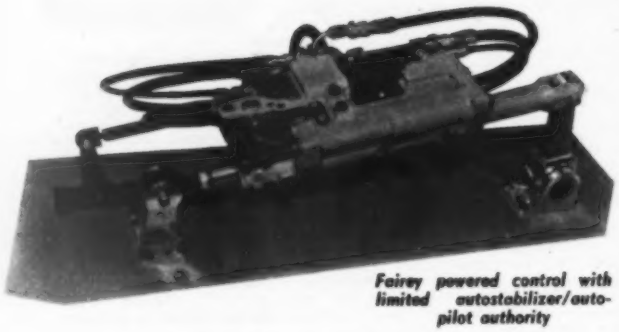
**Irving Air Chute** and the **G.Q. Parachute Co** both concentrated on other-than-personal 'chutes on their stands this year, but Irvin did show a seat-type parachute, the ES-63, designed for pilots of high-altitude jet aircraft without ejection seats (e.g., Vampire Trainer, Fouga Magister). This has a built-in oxygen supply and a barometric release.

**ROUND THE STANDS . . .**

# POWERED FLYING CONTROLS

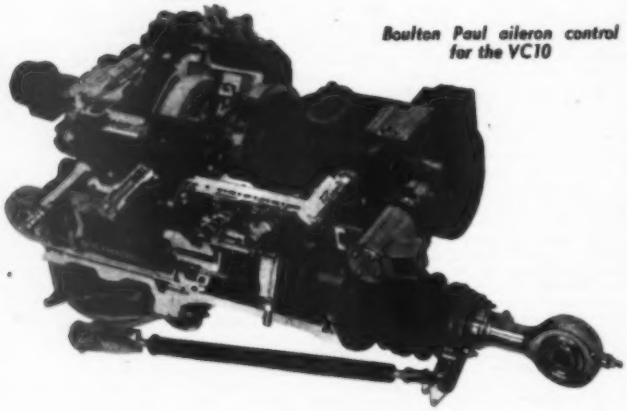


*Dowty servo actuator with manual and electrical inputs*



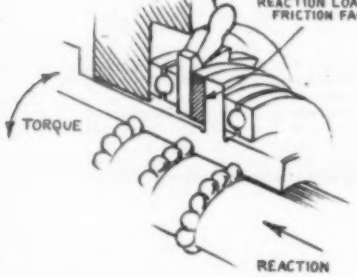
*Fairey powered control with limited autostabilizer/autopilot authority*

*Boulton Paul aileron control for the VC10*



*VC10 spoilers will be operated by this Boulton Paul jack*

*Hobson "No-back" ball-screw ratchet*




RATHER tantalizingly, the small number of new flying control units which appeared at the Show this year did not have their applications labelled. **Dowty** came nearest to being specific with a dual-input servo actuator, said to be for "a control surface of a vertical/short take-off and landing tactical strike aircraft"—which without too much of a guess can be identified as the **Hawker P.1127.**

The control operates in three modes: under manual input from the pilot's lever; by pilot's input on which is superimposed electrical autostabilization signals; and under autostabilization authority alone. Autostabilizer command is superimposed on the pivot of the input mixing lever to bias it in the required direction, but under the pilot's control is a solenoid-operated centering valve which can override and lock-out the autostabilizer bias. A second solenoid valve limits autostabilizer authority to half stroke for normal operation or permits full stroke when autopilot signals are superimposed on those from the autostabilizer. With this type of system fully automatic control from the ground should eventually be possible. Stroke of this jack is 1.8in, thrust 4,080lb and the unit weighs 11.5lb. It operates on DTD 585 at a system pressure of 4,000lb/sq in.

Dowty are also actively investigating all-electrically signalled systems for supersonic aircraft; in their view signalling channels from the stick must be quadruplicated to ensure freedom from spurious information.

**Fairey Engineering** showed another brand new unit, coupled in to the electrically signalled autopilot/autostabilizer system on which they have now been working for several years. This control operates on a 3,000lb/sq in system and has been made unusually shallow for installation within a thin wing. It would be a fair assumption that this unit is also destined for an aircraft like the Hawker P.1127, the flying controls of which may be made by Fairey. Hydraulically, it is completely duplicated, with two servo valves and two pistons on the jack.

Representatively mounted, the unit was coupled manually to a pilot's stick and could also receive electrical signals from an "automatic stabilizing computing system." These autostabilizer and autopilot signals are accepted by a Fairey electro-hydraulic servo valve operating a small actuator which is differentially coupled into the pilot's input. Because autopilot and autostabilizer displacement authority is restricted to about 10 per cent of the total stroke, the stick is not, in this system, latched in or out with change of mode, so that with the actuator under autopilot command, it remains stationary. When the autopilot or autostabilizer signals are switched off, or should they fail, out-of-trim protection is provided by a self-centering device which re-aligns the stick with control surface displacement. Reliability of the electro-hydraulic valve, incidentally, is now such that Fairey use it in place of a mechanical cycling system when actuators are undergoing type test.

Last year, surmise only was possible about the actual shapes of **Boulton Paul's** flying controls for the VC10. Now completed, these units are seen to be based upon other Boulton Paul controls which have nearly a million hours' flying experience behind them. Should a unit fail in the VC10 split-control-surface layout a valve across the hydraulic ram heavily damps the motion of the control surface as it trails to a no-load position. It is then mechanically locked.

Two units in each group receive autostabilizer/autopilot signals into a torque motor operating a secondary servo valve and actuator. In the autostabilization mode a differential linkage adds these signals to those of the pilot, but the differential is locked under autopilot command and the pilot's controls are moved by the ram output, keeping the system in trim. The loop is closed electrically by a position transmitter on the output which is fed back to the autopilot amplifier.

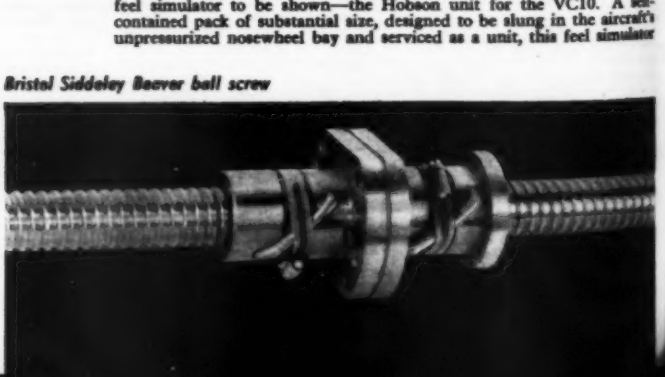
For the same aircraft, Boulton Paul are also manufacturing the spoiler jacks; this type of secondary control surface provides quite good business for flying control manufacturers. Ball-screw jacks are, for instance, being manufactured by **H. M. Hobson** for the leading and trailing edge flaps of the Trident. The trailing edge unit has two ball screws linked to the inboard and outboard flap sections; four jacks are used per side on the leading edge surface. Rolling rather than sliding contact results in a very efficient, and thus reversible, unit and the Hobson jacks incorporate the US-developed "no-back" ratchet and pad to friction-load the screw to less than 50 per cent efficiency against output loads. A range of ball-screw jacks is also marketed by **Bristol Siddeley**, the Beaver design having a minimum efficiency of 90 per cent, zero backlash, and the capability of operating dry at temperatures too high for normal lubrication.

No new powered flying controls were shown by Hobson this year, but the firm have pioneered the use of titanium for the cylinder body and ram of the 24,000lb thrust Sea Vixen tailplane jack, with a weight saving of seven pounds.

### Feel Simulators

ARTIFICIAL production of pilot's stick loads have come a long way from the simple spring, as is apparent from a glance at the only new feel simulator to be shown—the Hobson unit for the VC10. A self-contained pack of substantial size, designed to be slung in the aircraft's unpressurized nosewheel bay and serviced as a unit, this feel simulator

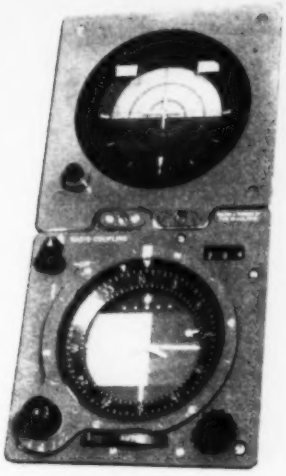
*Bristol Siddeley Beaver ball screw*



is self-contained and fully duplicated. There are two sub-systems, each of which comprises a 200v, three-phase 400c/s electric motor and hydraulic pump, a reservoir pressurized by cabin air, an accumulator and the feel system. The last-named, again duplicated for each axis of control, consists of conventional Hobson diaphragm-operated valves which supply Skydrol fluid pressure to static loading jacks as a function of the square of forward speed. In the case of the aileron and elevator, however, evacuated capsules are superimposed over the diaphragms to modify stick loading with altitude.

There are six jacks in all, two for each channel, and associated pairs are coupled through a differential lever—best understood from the wiffle-tree analogy with a coachman's six-in-hand. By this means a seized jack, or one which has lost pressure as a result of a failure elsewhere in the system, becomes a fulcrum for the differential lever and the live jack operates through twice the stroke and at twice the mechanical advantage. The feel force applied thus remains constant. Linkage on the aileron channel is arranged so that feel force increases non-linearly with control surface deflection as well as being varied as a function of dynamic pressure, and on the rudder channel a manual screw jack is provided to shift the linkage datum for trimming. All oilways are drilled in the main casing; there are no external pipes anywhere. Weight is rather over 25lb per channel, and the complete unit weighs around 165lb.

A complex box of bits and pieces, but designed for a 3,000hr overhaul period and for full fail-safe operation.



*Right, the new roller blind flight director instruments for the D.H. Trident with situation display showing blue and yellow ILS mode. Below, the integrated controller for the Trident's triplex autopilot*

# FLIGHT CONTROL

**Autopilots**

PROBABLY the most significant flight control development at Farnborough was the revelation of a good deal of new information on the triplex system for the D.H. Trident. Both **Smiths Aviation Division** and **Sperry** are involved; and Smiths have decided to break the near-silence they have maintained for years about their very extensive work in the automatic landing field. A two-hour session with A. M. A. Majendie and J. Rivaz of Smiths during the Show gave *Flight* the first details of some of the work which has already been done. Mr Majendie first noted that Smiths' work in automatics really dates from the pre-war Queen Bee target aircraft, even before the foundation of BLEU in 1947.

It was in August 1955 that, as a private venture, Mr Majendie himself wrote the first operational requirement for an autopilot suitable for continuous flight control and automatic landing. A detailed investigation of all-important safety factors and calculation of redundancy requirement led Smiths to the multiplex approach. They have said very little about how they solved the obvious problems of effectively running a triplex system but they have now stated that a multiplex simulator was running in 1956 to solve this problem and that, for more than two years, they flew a Dakota with a triplex elevator circuit under all flight conditions.

This work preceded any firm civil order and was done in parallel with BLEU development. From it resulted a homogenous multiplex system in which, for the first time, all the various functions have been integrated. They include multiplex autopilot, automatic throttle control, servo-operated director instruments, twin air-data computers, three vertical gyro references, twin compass systems, radio and navigation indicators, barometric and triplex radio altimeters, the PVD monitoring display and a single integrated control panel for the triplex autopilot and flight systems. Of the three types of visual monitor evaluated, director instruments, optical projection on the windscreen and PVD, the last-named proved most effective and has been adopted by BEA.

The first few Tridents will actually have duplex autopilot with a completely independent PVD flight director circuit forming an artificial third channel and there will be three vertical gyros and three complete radio altimeters with six aerials between them. As soon as the ground facilities have been brought up to automatic landing standard—an important requirement will be two completely independent airfield power supplies—this "2½" Trident system can be brought up to full triplex standard simply by the addition of components for which provision is already made. Smiths estimate that they could introduce fully automatic landing into service by 1965, but 1968 seems to them to be a more realistic date in view of the progress required in other fields.

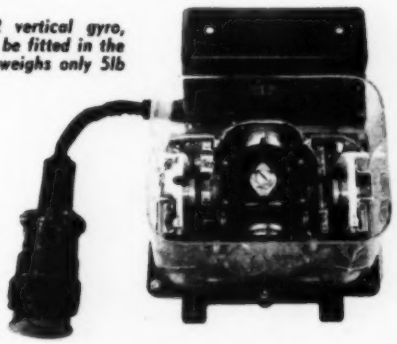
It is now a matter of national importance that firm support should be given to ensure that these 13 years of highly successful work should not be wasted. Bomber Command is already implementing the single-channel Autoland system in V-bombers and their bases, but more important still is the fact that the Short Britannic military freighter is to be fitted with a Smiths triplex automatic landing installation fully meeting civil reliability standards. This will be in service by 1964.

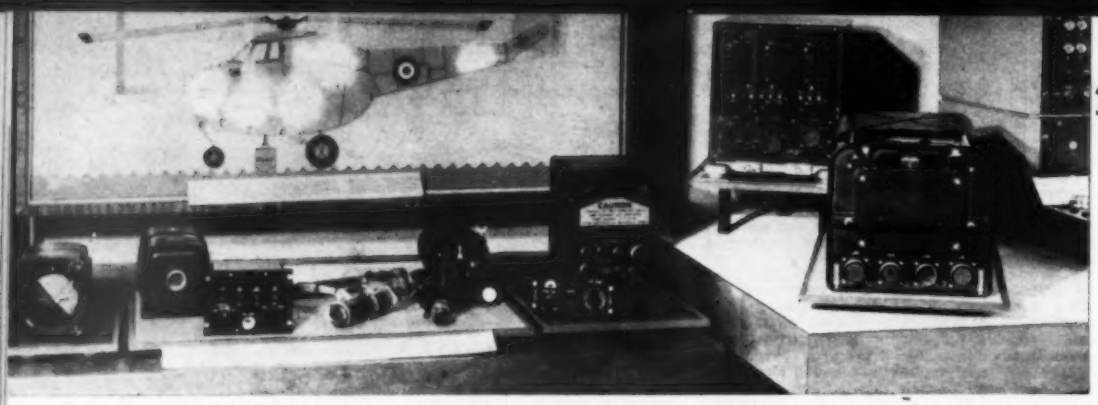
On the working of the triplex system itself Smiths say that a failure in one channel would lead to automatic cutting out of the failed channel without disturbance to the aircraft. Should the automatic disconnection not function a direct manual disconnection is available. If this in turn is unsuccessful the remaining two channels can over-ride the failing channel. More than two years of flying with the experimental Dakota have shown that this system is successful and nuisance cut-outs in rough weather, normally considered almost inevitable with such a fault-detection system, have been completely avoided. A channel failure cannot be disastrous and the required reliability of one in $10^{-7}$ could be proved in 4,000hr of flying. Smiths in fact expect their reliability to be nearer one in $10^{-9}$ than one in $10^{-7}$; and a higher component failure rate need not necessarily affect over-all safety. Reliability estimates have been based on a detailed analysis of Smiths autopilot equipment which has actually been in service with BOAC and other airlines for some years. Mean time between failures of every sub-component has been analysed and the results extrapolated into the new equipment. The MTBF in service is forecast at one in $10^{-5}$. Smiths emphasize that no one component in the system needs to have better than normal performance and that individual units could be changed on the airline routes without having to be matched or lined up with others. Another important point is that the personnel who will service the new equipment are those who have already been dealing with the older equipment for some time. The SEP.4 autopilot is the civil version of that used by the RAF for Autoland and the SEP.5 is the multiplex equipment specifically designed for the Trident.

Discussing the possible desirability of eliminating leader cable from the automatic landing sequence, Smiths said that they have made many hundreds of landings with ILS localizer guidance alone. A single guidance system is preferable in order to avoid switching during the automatic sequence and Smiths feel that ILS-only landings can be achieved. The new S.T.C. ILS at London Airport appears suitable. An illustration of the kind of performance now being achieved by Smiths is the incident quoted in *Flight* for February 19 when Smiths personnel were taken from Staverton to Hatfield in a Varsity which made an ILS-only automatic landing in conditions when fog on the roads would have made a journey by car very difficult. A major factor in Smiths work is that they have years of experience of operational testing of automatic landing equipment and that their claims are based on practical experience and specific research unequalled anywhere in the world.

It has been said that pilots would find difficulty, during an automatic flare-out, in controlling aileron and rudder manually while elevators were under autopilot control. But Smiths have proved in flight tests that this can be done; and they have also experimented with a pilot

*The Sperry VGL.2 vertical gyro, three of which will be fitted in the Trident. The gyro weighs only 5lb*





*Newmark Mk 19 ASW helicopter autopilot with, l to r, attitude indicator, vertical gyro, pilot's controller, cables, barometric unit, compass controller and unit and main computers*

## Round the Stands . . .

using instruments to direct him on one axis and the direct visual contact for other axes. Perhaps the major factor which Smiths have proved is that the triplex system is a successful way of producing an autopilot which has greater control authority than it could safely misuse.

Sperry are associated with Smiths in the development of certain portions of the Trident flight control system, and particularly provide three VGL.2 vertical gyros and two C.11 Rotorace compasses. The VGL.2 is a gyro of normal performance but 3lb lighter than the previous Sperry unit or others of its kind. A weight saving of 9lb is thereby achieved in the three gyros employed. One feature is a steel gimbal ring which provides good temperature compensation. The azimuth gyro has been duplicated mainly to ensure stand-by service for the drift kick-off phase of automatic landing; and azimuth reference is raised to "2½ channel" level by the presence of the normal magnetic stand-by compass as an additional monitor.

So far Sperry have produced about 40 Rotorace systems, most of them CL.11Fs intended for the Fiat G.91. Rotorace provides a near-inertial quality azimuth reference suitable for combination with the Bendix Doppler in the G.91; and azimuth indication in the cockpit will be on the indicator of the PHI navigation computer. The VGL.2 vertical gyro has been chosen as a standy-by gyro reference for the Litton inertial platform in the German F-104G. Stand-by azimuth indication will be by modified CL.2. Sperry are also producing the twin Rotorace master reference gyro which stands fair to become a replacement for the RAF MRG.1 and has also been designated as the short-term inertial element of the Doppler-inertial system for the French Mirage IV. The Doppler element in this aircraft is the Marconi AD.2300 —an important British contribution to this French supersonic bomber. Sperry in America produced the inertial platform providing flight reference for the X-15. At first, this employed Minneapolis-Honeywell MIG gyros but these are now to be replaced by Sperry's own SIG.1000 miniature gyros. Sperry are now offering a modified version of the X-15 platform with SIG.1000 gyros in an inertial system whose performance is claimed to be better than that of the remarkable Litton system for the F-104G.

New portions of the Trident system shown for the first time on the Smiths stand included the combined control panel for the autopilot and its various height, speed, coupling and automatic landing phases. Airspeed or height may be selected on veeder indicators, selected heights captured from climb or descent, and i.a.s. altered by progressive selector like the conventional pitch-knob. A changeover switch allows either flight system to control the autopilot, so that one may be in use while the other is being set up for the next operation. Doppler track coupling is also included. A further panel allows verification of individual portions of the overall system.

Trident instrumentation evidently includes an almost completely new set of flight instruments centred on roller-blind attitude and navigation displays. The technique is broadly similar to that of the traditional SFS in that the attitude display is the main flight director with the navigation unit as a situation display and mode selecter rather than a "live" director. A roller blind here presents VOR position, course line or blue and yellow ILS display with a glidepath cross-pointer. The automatic landing monitor instrument is basically the radio altimeter indicator with marker lines at 150ft and 30ft to show beginning of attitude hold and flare-out phases. Warning flags show engagement of the phases.

A new concept in instrumentation is the servo-operated a.s.i. in which the needle revolves through two turns. The dial face is spiralled so that, at low speeds the full length of the needle points at the outer scale. At 250kt the second turn starts and the end of the needle disappears behind the outer scale and points directly and only at the inner scale. Ambiguous speed readings are thus avoided. The v.s.i., also being servo-operated from an air data computer, reads up to ±7,000ft/min. The altimeter is a version of the servo-operated counter/pointer type with veeder indication down to the nearest 50ft and a single needle reading from 0-1,000ft intervals. Thousands of feet are shown only by direct counter numbers, eliminating traditional 0 or 10,000ft confusion. It is reported that BEA are considering fitting all their aircraft with such servo-operated altimeters on the first pilot's panel.

A developed version of the SC.1 autostabilizer and control system, whereby pilot demands are superimposed on autostabilizing signals, was shown on the **Short** stand, together with a location drawing of the components in the PD.49 VTO fighter. Attitude references are six Smiths miniature gyros, three for pitch and three for roll. Hydraulic servo movements are sensed by AC pick-offs and fed to the fault-detection unit where they are compared with each other and with gyro signals in a sequence by which one or two faulty channels may be identified. Separate switches on the pilot's control panel allow individual elimination of any pitch or roll channel when a red light shows a failure. Printed circuitry and potting is extensively employed. Development of an effective fault-detection system was one of the main tasks for the SC.1 autopilot and this has now been done. The developed system exhibited is soon to be installed in the second SC.1.

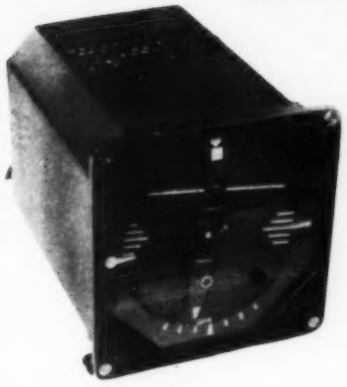
**Newmark Technamation Division** have evidently been working for some time to anglicize a Lear automatic anti-submarine control system for helicopters called the Mk 19 autopilot. It probably applies to the Wessex and incorporates very comprehensive facilities for automatic hovering, (a) stationary with reference to a ground or water surface with the aid of Doppler, (b) stationary in space by short-term inertial reference, (c) vertically over a suspended buoy which may be drifting in a tidal current. The Doppler resembles the Ryan APN-97 ordered by the Navy for the Wessex. Barometric height lock is provided for normal conditions, but radio altimeter or a pendant cable may be used for precise height control. Standby remote-gyro attitude indication is provided and any of the four control axes may be individually switched off. Newmark also showed portions of the light helicopter autopilot for stabilization alone as well as manœuvre, heading and height holding using flight instruments for reference. It weighs 50lb. Newmark hold the licence for the Lear MARS, two-gyro remote attitude system already ordered for the American F-105, F-106, F4H and A4D-2.

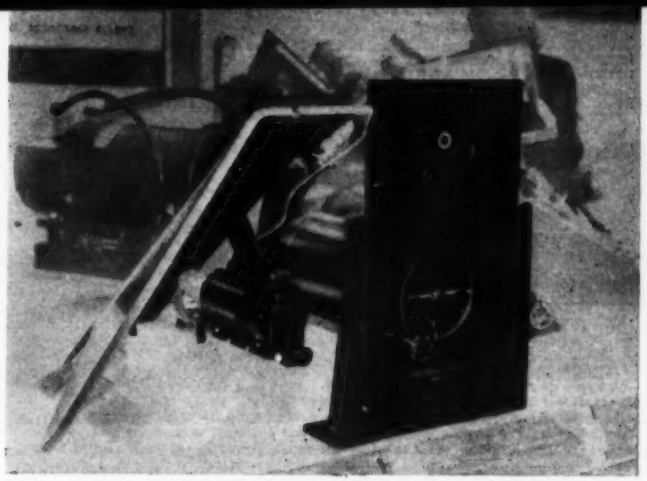
A newcomer to the English scene is the Minneapolis Honeywell universal adaptive autopilot which, it is claimed, adapts itself in flight to any conditions of turbulence, speed or height. It was designed in America and is being offered for sale or manufacture by **Honeywell Controls Ltd** in Britain. Considerable Continental interest already exists, the same autopilot unit being suitable for any type from fighter to VTO aircraft.

Little was to be seen this year of the **Elliott** autopilot equipment for the VC10, the other automatic flare-out airliner now in preparation. A computer based on that of the Bendix PB-20 showed the modules which are being incorporated in the Elliott system and an automatic throttle control unit was shown. This last facility is apparently being introduced in Fleet Air Arm aircraft.

More significant were certain components of two military autopilots being developed by Elliott for a supersonic fighter aircraft now entering service. A feature of the control panel of one of them was the use of mechanical interlocks between mode selecters to save panel space. A climb setting covers optimum climb performance under autopilot control and the inclusion of "track" and "glide" switches indicates automatic or near-automatic landing. Automatic throttle control is included. The main hand control is designed for use with the right hand outside the field of vision. Airpass has a controller for the left hand. It was stated that the autopilot hand controller could govern either extent or rate of turn, according to the mode in use. The barometric height lock is

*Pilot's controller of the Elliott autopilot for a supersonic fighter*





***Left, the Ferranti attitude indicator for the new helicopter instrument system. Above, Ferranti remote indicating standby instruments, including windscreen-mounted directional gyro***

## Round the Stands . . .

monitored, especially at low altitudes, by a radio altimeter to avoid excessive pitch demands. Just before Farnborough, Elliott showed a rather larger military autopilot the control panel of which included a selector for the LABS manœuvre, a feature also included, we note, in the Ferranti light fighter attack sight (these two items of equipment are not related). Both the military autopilot computers were as closely packed as any equipment of this nature can be and showed evidence of the desire to save space at all costs, at the inevitable expense of accessibility. There was little of the plug-in module approach now preferred by civilian operators who increasingly want to remove a faulty module rather than a whole black box during apron servicing. It seems that the military units are themselves so relatively inaccessible in the recesses of the aircraft structure, that sub-component accessibility is a minor asset.

### Gyros and Instruments

Precision Gyros for inertial navigation and related uses were more common at Farnborough than in any previous year. English Electric Instrument Wing are producing the Minneapolis-Honeywell GG.49 miniature floated gyro under licence and Ferranti are improving the Kearfott gyro which they produce under licence. Just before Farnborough, Elliott Brothers for the first time exhibited a wooden model of an inertial platform and it has been known for some time that they provide the guidance for Blue Steel. Ferranti gave some details of the stable platform Type 100 intended for a future aircraft application. It is a four-gimbal system using two Minneapolis GG.49Ds for vertical stabilization and a Kearfott T2502-3D as the heading element. The latter can indicate accurately without external assistance for some hours so long as the appropriate corrections are applied, and the GG-49s can provide short-term inertial reference. Three Kearfott force-feedback accelerometers made by Ferranti are included and coarse attitude and precise pitch and heading outputs are provided. The platform weighs 64lb including internal electronics and measures 18½in × 12½in diameter. Some 2lb/min of cooling air at up to 35°C are needed.

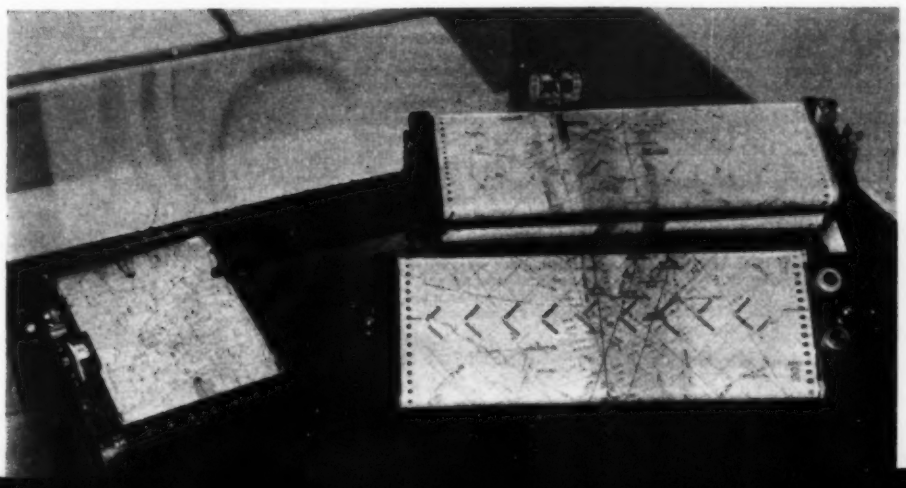
Other gyro systems included the Gyro Twin (formerly MRG.2) by S. G. Brown and their Arma Brown high-accuracy compass for helicopters. For use with standby instrumentation in aircraft with master reference systems, Ferranti have developed the vertical signalling gyro unit, and control inverter to operate either from AC or DC supplies. They feed the new FH.7 Mk 6 standby artificial horizons and FDI(M) directional indicators which may be magnetically monitored if necessary. The complete equipment weighs 18½lb and includes gyro, DI and horizon and inverter unit. One version of the DI is designed for mounting on a windscreen strut in order to save panel space. The Gnat Trainer has this type of standby instrumentation. It is noteworthy that even standby instruments are now employing remote gyros.

Currently under development by Ferranti is the Helicopter Instrument System comprising a director horizon and a hover and navigation display with associated computers and dynamic references. It is intended to allow a pilot to monitor automatics, to fly the helicopter under directed manual control and to teach pilots to learn and practise advanced instrument flying in helicopters. Broadly, the system consists of a vertically mounted attitude display with a director symbol traversing a conventional attitude display, above and beside which are respectively yaw and collective-pitch directors. Mounted horizontally beneath the attitude display is a situation display based on a rotating compass card and heading selector within which one of four navigation displays—landing, hover, mid-course and ILS—can be selected. To right and left of the compass dial are rotor r.p.m., linear director and height deviation indicator. Height datum, heading selector and operating mode controls are provided.

The attitude indicator has been made as large as possible in order to provide high reading sensitivity without excessive instrument sensitivity. The hover mode of the navigation display would take signals from a two-axis Doppler; and a Doppler altimeter signal could be used in the height deviation indicator. The mid-course mode shows range rings and bearing for point-source navigation. The ILS mode shows an arrow representing localizer position while glide-slope appears on the height indicator. In the landing mode a tram-line course indicator and range bar show the plan-position relationship of the helicopter to a selected touchdown point. The hover display is based on a rectangular grid which repeats the helicopter's movement over the ground. No specific application for this system has been published, but it could evidently have an important place in both civil and military helicopter operations.

Pictorial navigation presentations are now taking more definite shape. A **Kelvin Hughes** roller map was displayed this year in modified form, still incorporating magnetic ink navigation reminders printed on the reverse of the chart. Kelvin Hughes are moving towards an area display back-projected from a film to overcome the track limitations of the strip map.

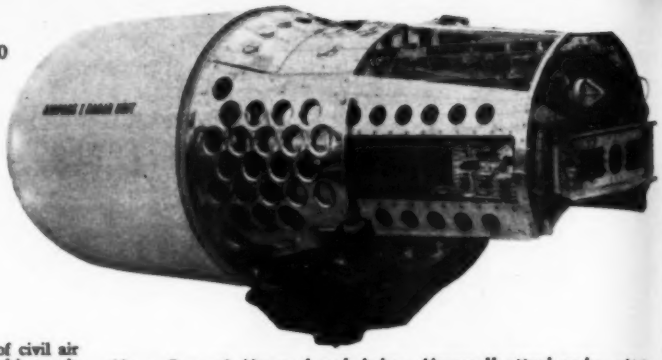
**Decca Navigator** have continued development of the roller map, based on Flight Log know-how using either Doppler or manual groundspeed inputs. The unit weighs 5lb and can take a cassette covering 2,400 miles at ¼ million scale or 1,200 miles at ½ million scale. Omnitrac, described on page 472, can be used to drive the new Flight Log 331B which has a nine digit self-setting system which makes it totally self-setting and has an undistorted chart over-printed with Decca hyperbolae. Incidentally, Decca Mk 8 was shown this year in a ½ ATR case which included a transistorized power unit. Decca have proposed for the Trident a pictorial chart driven by Decca-type impulse computer which could accept XY information from any aid, including Doppler and inertial. Two pens would trace tracks from two navaids, a divergence indicating inaccuracy in one or other source. Such an arrangement would be flexible and self checking.



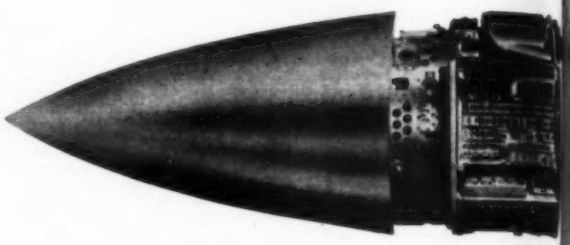
***Decca roller map, on left, and Type 331B Flight Log and spare map cassette for use with Omnitrac, Doppler and 9-digit, complete self-setting facility***

**Round the Stands . . .**

# RADIO AND ELECTRONICS



*Above, Ferranti Airpass I and, below, Airpass II attack radar, which contains more transistors*



ALTHOUGH still in the speculative stage, future systems of civil air traffic control made their mark on the electronic exhibits at this year's Show. Not only was new equipment for such systems to be seen but evidence of the growing realization of the need for basic research and rethinking on certain aspects of systems operations could be discerned. At present, tenders are in for air traffic control equipment for two years experimental assessment by the Ministry of Aviation; the Apollo computer for Oceanic Control is expected to start experimental operation this winter.

Holding some promise as a new long-range navigation aid, the VLF propagation studies being carried out by **RAE Farnborough Radio Department** aim at discovering the potential accuracy that could be expected of a VLF global navigation system. Two fixed stations at Rome and Malta monitor GBR Rugby on 16.0kc/s continually, recording the received signal. A third set of apparatus is carried in a Comet.

For measurement purposes the phase of the received signal is compared with that of a high-stability local oscillator. Care has to be taken that the portable version of the oscillator, used in the aircraft, does not change in phase or frequency when transferred, for example, from the laboratory to the aircraft. The crystal-oven heater supply has to be continuous and batteries for this have to be fitted into any vehicle carrying the oscillator. In the aircraft, twin inverters supply the oven from the bus-bars; and should the bus-bar supply fail the oven is switched over to a stand-by battery. Twin ovens are used and the total oscillator drift amounts to 1 part in $10^9$ per week.

At the wavelength being investigated, the ionosphere and the earth's surface form a waveguide with a width of about two wavelengths. Variations in the height of the ionosphere cause variations in the transmission times of reflected waves. In Malta the transmission time varies by about 18 microsec between day and night. This would correspond to a position error of about three nautical miles.

As the aircraft oscillator is flown away from Rugby, the phase change between the received signal and the high-stability oscillator signal is measured continually. There is about 36° phase shift per nautical mile. The present transmission from Rugby is a keyed carrier transmission carrying Admiralty messages and the fact that the key may not be depressed for long periods can cause a miscount in phase change. A practical navigation system would require a continuous wave. It is envisaged that a comprehensive system would require six transmitters: four spaced around the equator and two close to the poles.

The receiver in the aircraft employs a twin IF amplifier operating at 525c/s. The bandwidth is 1c/s. A common local oscillator is used to produce the twin intermediate frequencies and the twin amplifiers are used to cancel out phase changes in the receiver. It is also possible to use the high stability source as the local oscillator.

The high stability oscillator is equipped with double ovens operating at 90°C, controlled to within millidegrees. From the fundamental frequency of 5Mc/s, frequency division is carried out to yield 100c/s pulses, which act as a universal reference for the system. Multipliers provide the various harmonies for comparison with the received signal. In addition the 100c/s pulses are divided by two and shaped to drive the synchrous motor operating the chart recorder.

The narrow bandwidth of the receiver yields a reasonable signal/noise ratio in this noisy part of the radio spectrum. The effect of the proximity of whistler paths to the line of propagation is to be investigated later. The line of magnetic force along which whistlers are propagated from the Rugby area has been calculated to return to earth somewhere near Cape Town. Flights will be made in this region to discover whether any navigational difficulties arise.

Various aerial systems are carried by the Comet. A long wire (it is only a fraction of a wavelength at VLF) extends along the top of the fuselage; a balanced dipole (also a fraction of a wavelength) extends its arms either side of the fuselage; and a loop aerial is carried in the aircraft structure. The aircraft normally flies at its economical cruising height of 40,000ft.

At present, navigation with the VLF system is carried out in retrospect in the laboratory, after the flight. Little accuracy could be expected with the initial Rugby-Griggion base line used, as the two transmitters are only 50 miles apart. To test the system more realistically as a navigational aid, the transmitter at Balboa in the Panama Canal zone will be used as one end of a base line.

As a global navigation system, VLF offers certain advantages over satellite systems. It provides a continuous means of determining position fairly cheaply, whereas a satellite system would require several expensive satellites if time gaps between transits are to be avoided. Such gaps would be embarrassing during very high-speed flight. The strategic advantages of one system over the other are debatable.

The key to automatic flare-out, automatic landing, automatic data links, and automatic air traffic control is reliability. The problem under discussion at present is how much reliability is required and how much can be expected of a given system. From their exhibits it is apparent that **Elliott Brothers** and **Smiths Aviation Division** are working on these questions as they apply to automatic flare-out and landing and **Cossor** are studying the reliability of air-to-ground data links—which are likely to be an essential part of air traffic control systems using digital computers.

The Elliott approach to reliability in their autopilot and automatic flare-out equipment for the VC10 is to arrange for components likely to fail to do so dormantly. This is rather like putting redundant struts and ties into a bridge instead of building a second bridge alongside it. If a component within a circuit fails then the rest of the circuit is designed so that it can bear the increased burden imposed on it and still function within its operational limits. Certain components not amenable to this treatment, such as microswitches, are duplicated or triplicated.

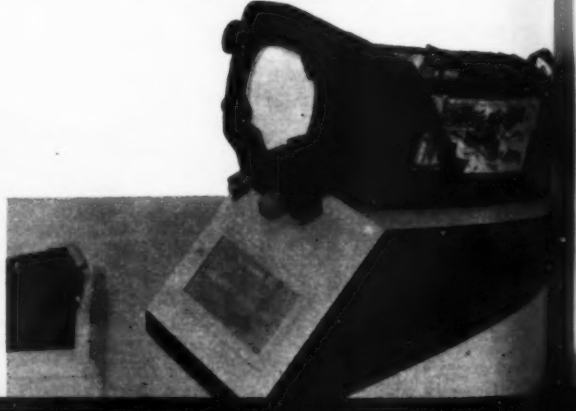
In addition the company are using other reliability techniques. High integrity engage circuits are incorporated. Engage mechanisms in the autopilot, for example, derive their power supply from within the autopilot at a voltage, source impedance, and isolation chosen to be quite different to any other voltages in the aircraft. In this way the risk of maloperation due to leaks from other circuits giving spurious signals is reduced considerably. One point becoming increasingly clear as work on reliability circuits develops is that rigorous quality control and testing of components will be necessary in future systems.

The double-channel philosophy could be seen in the new range of airborne communication and navigation equipment exhibited by **Marconi's Wireless & Telegraph**. The type 6404 glide slope receiver, for example, is made up of four sealed modules: r.f. oscillator, r.f. amplifier, i.f. amplifier and filter unit. It is contained in a short ½ ATR case and provision has been made for the addition of a second filter unit into the case should the receiver be required for a duplex automatic control system. Only the filter is duplicated because it is the only module that would produce a misleading output if a failure occurred within it.

Half of the units in the new Marconi range are made up of sealed modules. They are pressurized with a dry inert gas and the seal can be easily made or broken. Magnetrons in sealed modules have brought something of a bad name to this type of packaging, but as the new range does not have such energy dissipating elements within the sealed modules, a gain in reliability is likely to be achieved by the method. The only relatively untried components in the system are the VHF transistors, particularly in the higher frequency region of the glide-path receiver. Life tests by the company indicate that little trouble is to be expected from these, and the units will themselves be well tested by the time they come into service in the VC10.

Cossor are assessing the reliability of a data transmission system in the frequency range 3-22Mc/s to discover the limitations imposed by

*Search display of Airpass II with, visible on the left, the left-handed ergonomic controller which incorporates two knobs and seven switches and a rocking palm rest*



*Standard Telephones QA 8 field test set with which complete functional checks can be made on airborne VOR/ILS equipment*

propagation difficulties. Ultimately such a system could be used in transatlantic flights for the automatic transmission of data such as height, position, identity, destination to air traffic control centres. A transmission system that could be simply installed and would make use of the existing HF transmitter in an aircraft making routine flights has had to be used; so that the type of transmission used is not ideal and would be modified in an operational link.

Previously, there has been no information on the reliability of such data links, although most plans for introducing automation into air traffic control assume it can be done.

A piece of equipment which may have significance in this respect was exhibited by **Redifon**. Their new GR410 transistorized single-sideband transmitter-receiver for 3-18Mc/s produces 100W p.e.p. with a d.c. power consumption of only 7W. Single-sideband data transmission would probably suffer less from fading than the present system of double-sideband transmission. The GR410 is designed for mobile use but not specifically for aircraft; but it is reported that the UN are considering using the equipment for communication between aircraft and vehicles in the Congo. It seems inevitable that SSB will become standard for aircraft HF communication as bands become more congested.

A radar tape recorder suitable for recording air traffic movements for retrospective analysis was shown by **Decca Radar**. An Ampex VR 1000B Videotape recorder has been modified by the addition of units built from the Decca Interscan display system. Advantage over film projection techniques is gained in the more detailed and realistic display made possible by the greater dynamic range of the tape system. Data from single-beam surveillance radar can be accepted with a bandwidth of 20c/s to 3.6Mc/s, ±2db, together with speech in a bandwidth of 50c/s to 10kc/s. On a basis that the minimum usable signal is 6db above system noise, a linear useful dynamic range of at least 26db is available. A 14in reel of tape gives a playing time of 96min, making the equipment suitable for general training of air traffic controllers, investigation of transient "unwanted phenomena" on radar displays, and demonstrations of radar equipment.

Radar simulators for training air traffic controllers were displayed by Redifon. Target simulation is carried out by desk consoles, each of which is capable of simulating two targets. As the "drivers" for the targets are recruited from unskilled personnel, much care has been taken to make the simulator as easy to use as possible. In particular, much use has been made of push-buttons.

A transistorised tape recorder suitable for monitoring ATC voice communications was shown by **Thermionic Products**. The equipment continuously monitors all channels (20 on 1in tape) to detect malfunctioning. If a fault appears on one channel it is automatically switched out and the signal transferred to a standby channel. If a fault occurs on two channels a complete standby recorder is switched in.

Another contribution for future ATC systems, the SSR4G Cossor secondary radar scheme was shown complete in its pre-production form this year. The circuit principles demonstrated by the prototype design last year are retained. It is noteworthy that a servo system slaves the remote secondary radar aerial to follow the primary radar aerial to within $\pm\frac{1}{2}°$, a 400c/s system being used to obtain quick response.

Also looking ahead to future ATC systems, **Standard Telephones and Cables** showed their PVT2 automatic DF triangulation system. Whereas the PVT1 system displays bearing indications by projection of lines on a wall map, the new version provides a television display suitable for distribution to any number of monitoring screens. Bearing indications from various DF stations on individual cathode ray tubes are combined optically to provide a miniature triangulation display which is viewed by a closed circuit television camera. There are facilities for plotting aircraft positions, identities, and tracks so that they appear on the television monitor display. Work on the extraction of bearing data in digital form is under way.

STC also showed their STR-40 radio altimeter for the first time. This is a single-range instrument (500ft) designed for automatic landing systems. Displayed with it was the QA10 test set for this altimeter. If the altimeter shows a fault on operation of the confidence check switch in the aircraft, the main unit is removed and returned to the laboratory, where it is plugged into the QA10. The test set is used for both checking and aligning the unit to the required accuracy. It is not yet in production.

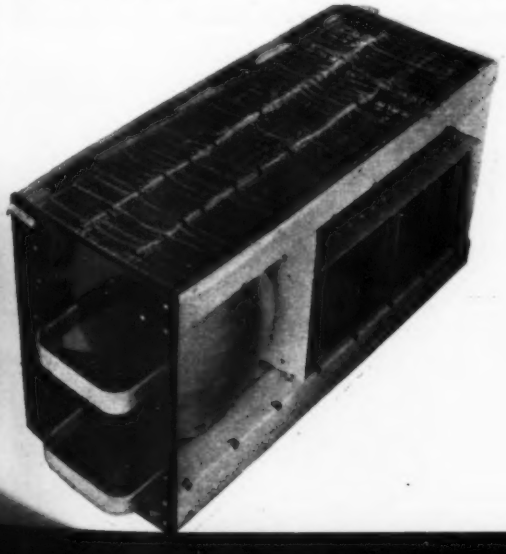
Other test sets displayed by the company included QA9 (ILS/VOR tone generator for accurate setting up of equipment), and QA8 (portable transistorized test set for airborne ILS/VOR requirements). The latter unit achieves its coverage in the 300Mc/s band by addition of a 200Mc/s oscillator signal to a 130Mc/s signal. In general, civil equipment at the exhibition exhibited this upper frequency limit of about 200Mc/s for transistor operation. Some of the military equipment, particularly in the telemetry field, gave the impression that transistors were being used there at still higher frequencies. It is generally felt that UHF transistors will make their appearance in civil equipment in the near future.

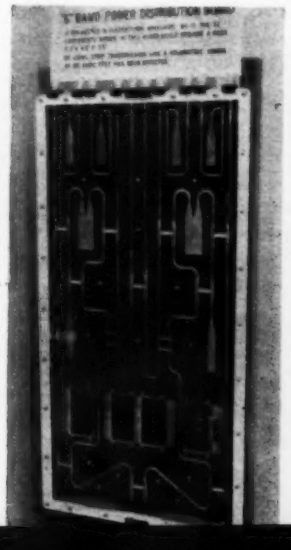
**Ekco** weather radar (E190), in keeping with the growing practice of duplicating essential services in aircraft, can now be installed as a duplicate system. The equipment includes two transmitter/receiver units and two indicator/control units operating from a single scanning unit in the nose of the aircraft, it being possible to mix units from different channels. The nose unit is basically similar to that of the E190 single system, but the servo motors have been duplicated and the RC circuitry associated with the servos has been taken out and built into the back of the duplicated receiver/transmitter unit, in the new interlock compartment; the whole assembly becomes a long full ATR. The aerial unit is fitted with twin synchros to drive the independent time bases.

**Ferranti** took some of the covers off Airpass I and Airpass II radar. Airpass II is a radar fire-control and bomb aiming system provided with additional facilities compared with Airpass I and developed as a private venture. Contour mapping, to assist in hill avoidance and to assist descents on to difficult airfields is included together with terrain clearance, or profile flying, facilities.

A dead reckoning navigational computer is available for the equipment, equipped with push-button inputs. When pre-set co-ordinates of points on the aircraft's route are fed in by pushing the appropriate button the computer will indicate the range and bearing to the point. It will operate from Doppler, air data or an inertial platform and is integrated into the radar display to present the range-bearing information as a deflection of the target spot or as a marker circle on the ground-mapping display. Inspection of the equipment shown indicates that many more transistors are used in Airpass II than in Airpass I.

Particularly interesting is the new version of the pilot's hand control for the equipment. This is shaped for operation by the left hand only, conforming to its contours. Overall movement of the palm operates a rate control of the target spot, instead of the positional type of control used in Airpass I. In addition, the hand control also manages to





*Left, the first Decca Omnitrac computer. Off-the-shelf components have been used and the memory drum is behind the front of the case. Right, the Cossor S-band power distribution board with 32 components* *(described on page 472)*

## Round the Stands . . .

incorporate two knobs and seven switches. Its sculptured ergonomic design could well be the forerunner of a whole new family of flying controls—particularly for high-g environments.

Cossor displayed further developments in their range of strip transmission lines, including a 32-component S-band system occupying less than 1 cu ft. The strip is ideally suited for mixing radar signals in receiving aerial systems where space is highly restricted and it has found application in homing radar devices where the strengths of the signals from two receiving aerials have to be compared. Also displayed by the company was a continuously-variable quartz delay line suitable for analysing pulses between 50 and 80 microsec. One application is in ECM for analysing hostile radar signals and an airborne version of the present laboratory analyser seems a logical development to be expected.

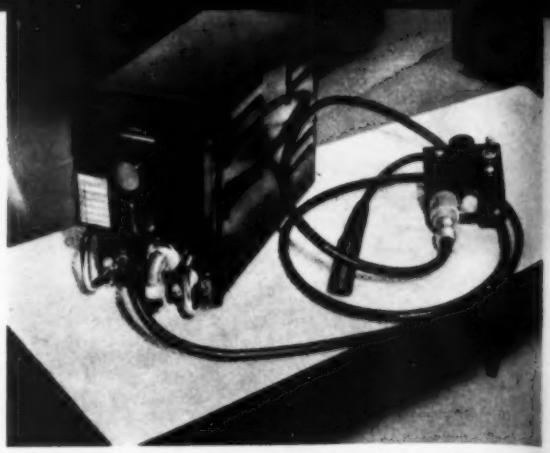
Continuous wave radar—a counter measure to jamming techniques for pulsed radar—was displayed by **AEI**. The unit was intended for illumination and tracking of targets for the Bloodhound Mk II weapon system.

Extension of radar range is promised by the parametric amplifier under development by Marconi. An Adler tube is used and the fast-wave nature of this device offers a reduction in noise level in comparison with the normal travelling-wave tube. Further advantage is gained by the use of a pump frequency exactly double the signal frequency. Tests with an amplifier coupled to one of the company's standard radar aerial arrays have shown that the device is a worthwhile line of development to pursue; but figures for improvement in sensitivity do not mean much at this stage of the investigation.

Marconi have also produced a track guidance computer to Arinc 543 for operation with their AD2300 Doppler system. Two legs of a flight plan can be fed in at a time and automatic changeover can be effected if required. Ministry of Aviation tests have shown the AD2300 mean accuracy to be +0.2 per cent over land and −0.3 per cent over sea; track angle was accurate to 0.1°. The problem of "altitude holes" has been overcome in the past year by modifying the transmitter output so that the critical altitude at which the hole appears is continuously changing—which suggests the use of some form of wobbulation.

The company have also produced a squelch circuit for VHF receivers that adjusts the squelch level automatically by reference to the signal-to-noise ratio in the area being flown. It is incorporated in their type 6401 VHF receiver before the audio output stage.

**Decca Navigator's** Omnitrac computer for converting positional data given in hyperbolic co-ordinates by the Decca navigation receivers to Cartesian co-ordinates was on display for the first time. It is an airborne unit with a total volume of less than 1 cu ft, and, being built from off-the-shelf components, will be amenable to considerable further miniaturization. The simplified co-ordinate transformation equation which made construction of the small computer possible also yields the "ghost buoy" function as an incidental feature of the calculation; that is, the computer can provide guidance along a straight line track to any selected point. It is now possible to connect the Decca navigator to an autopilot.



*Burndept's five-channel light aircraft VHF radio, now ARB approved. Crystals can be changed in flight. Price has been stated as about £140*

Compression of the size of the computer is achieved by trading space for time: a magnetic storage drum is incorporated and serial calculation is used, the complete computation taking 0.6sec. Some 600 transistors and 800 diodes are incorporated in the calculating circuit and the digital computer's accuracy of 1 in 50,000 preserves the full potential accuracy of the Decca navigator system.

**Ultra** exhibited a compact communications control system for aircraft. Their type UA60 has a basic station box with 15 push buttons for the selection of communications channels (transmit and receive), intercom, and cabin address facilities on a panel 5¾in × 3in. Volume control is incorporated in the push buttons for all receive channels and the panel is edge-lit. Using transistors throughout, the equipment operates direct from the aircraft 28V supply. It is designed to meet US standards and simultaneous operation of any number of receiving channels is possible. There is an override circuit available, which ensures that all crew members receive priority messages at high level, irrespective of whether they have selected the intercom service.

Smiths Aviation Division have now put their case construction system for ATR form factors on the market as a standard packaging for electronics equipment. The full range of ATR widths in both short and long sizes is covered and "dog house," mounting trays, and associated backplates are available. Construction is based on modules fastened top and bottom to channels running fore and aft at the top and bottom of the cases.

# MATERIALS AND PROCESSES

COMPLETELY new materials, ingenious new applications of established ranges, new processes, advances in component size and complexity, all were to be seen in the Show this year. On the other hand, a good deal that was not new or had been shown many times before was displayed again, so that selective viewing was required by the aircraft engineer on the lookout for new ideas.

**Accles & Pollock** claim that they can make almost any type of tube from a great variety of metals. This claim was well substantiated by an exhibition of tubes in molybdenum, niobium, titanium and its alloys, tantalum, vanadium and zirconium, in shapes which should meet even the most unusual design requirements. Special thin-wall tubing well illustrated the difficult manufacturing problems which have been successfully overcome.

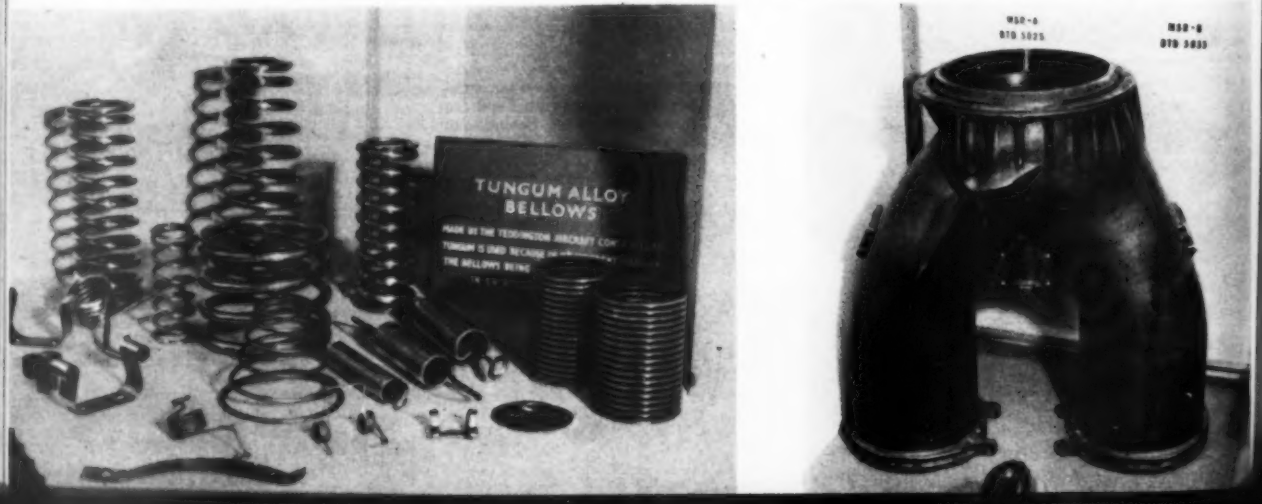
Of great interest is a new development carried through by **The Tungum Co**, who now supply "Tungum" alloy springs and spring pressings. As well as being non-magnetic and of high thermal conductivity, these are corrosion resistant, and meet the requirements of specification DTD 5009, and merit the consideration of those already familiar with the very well known "Tungum" tubes marketed by the same company.

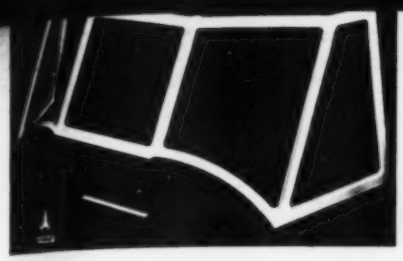
An unusual exhibit, shown by **Reynolds Tube Co**, was a rectangular flash welded ring, dished along one axis. It is made by a process which allows considerable economies by minimizing machinery, where several flange rings can be machined from one flash welded ring. In addition, products of the Reynolds hollow extrusion process were shown, which form the basis for hydraulic cylinders, jacks and pressure vessels.

Also specializing in hollow and solid extensions is the **Chesterfield Tube Co**, who showed beryllium tubes, a metal in which interest is steadily growing.

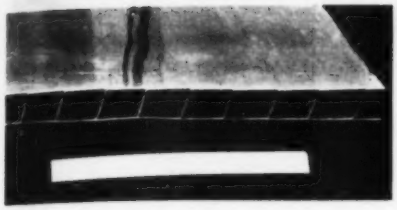
In the selection of bolts, great difficulty arises from the very multiplicity of types, each with its particular advantages in strength, lightness, ease of locking, or economy in manufacture. Touching only the highlights, **Acton Bolt**, as well as supplying a great range of bolts, exhibited thread-rolling equipment whereby threads and profiles can be generated from the cross-slides of single and multi-spindle automatics. The production engineer, to whom this is of the greatest interest, benefits from the

*Left, springs from wire and strip in Tungum alloy and, right, a large magnesium-base alloy casting in MSR alloy by J. Stone & Co*

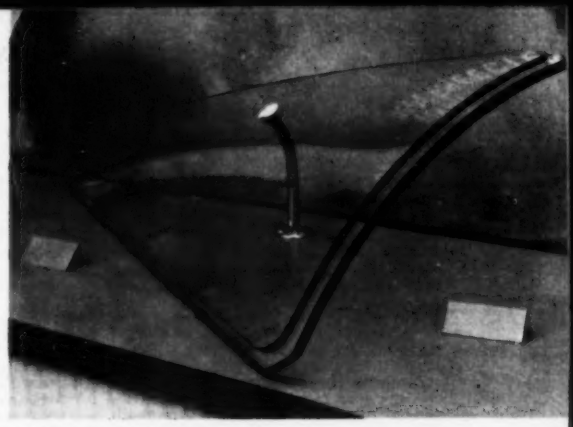




*Sterling Metal's casting for the Rotodyne windscreen frame in RZ.5 alloy*



*Section of Northern Aluminium Company's ducted sheet*



*Triplex Safety Glass temperature-resistant laminated windscreen panel*

## Round the Stands . . .

15 years' experience in the design, construction and operation of this equipment by the company. The advantages of rolled threads are widely recognized.

**Unbrako Socket Screw** showed high-performance bolts which can be locked in a most ingenious manner, even when used without Unbrako stiff-nuts. A short film showed convincingly how the new geometry of the bolt head is used to effect the locking operation. Additional strength is imparted to the bolts by the attention paid to the correct flow-lines in the head of the bolts. As well as high tensile steel bolts, titanium fasteners are offered with the same attention to metallurgical detail.

An interesting range of self-tapping bolts for aircraft which give a dowel effect by means of a stepped hole and a plain full diameter under the bolt head were shown by **Guest, Keen & Nettlefolds (Midlands)**. Hollow steel bolts of high tensile steel are also being exploited by GKN by a very clever balance of cold work, heat-treatment and geometry, to ensure that the section strength is properly distributed between hollow shank and solid thread. The result is a fastener with the mechanical properties of a 55-65 tons/sq in bolt with a 10 per cent to 20 per cent saving in weight. Tensile, double shear and fatigue data are given to show the quantitative advantages of this method of fastening. Ultra-high-tensile bolts are now produced by GKN without the danger of hydrogen enbrittlement during pickling and plating, as well as by the use of a steel resistant to this defect. A fine surface finish, shot peening and thread rolling enhance resistance to fatigue.

**J. Stone & Co. (Deptford)**, in addition to a considerable output from their Rivet Division, showed two very interesting magnesium-base casting alloys, MSR-A and MSR-B, which have achieved official recognition as DTD 5025 and DTD 5035 respectively. Information given by the company shows that good consistency is shown by cut-up tests, and that the properties are good in heavy sections. Many other advantages may be briefly summarized by saying that these two alloys represent an advance in almost every aspect over other magnesium alloys, except that, understandably, they may cost a little more. These alloys require a two-stage heat treatment to develop their full properties.

If a component is required of such a shape that it cannot be forged, extended, fabricated by welding or machined from the solid, then it is quite possible, and indeed probable, that it can be cast by one or possibly all three foundry companies exhibiting this year. **Sterling Metals** offer sand, die, and precision-mould castings; a very striking example was the Fairey Rotodyne window frame in magnesium zirconium alloy RZ5.

In the wrought metal field the **Northern Aluminium Co** showed three quite new developments. Noral B19S is an aircraft plate that retains good mechanical properties at elevated temperatures, suggesting applications for structural parts near the engines, and where kinetic heating may be encountered. "Noralduct" is plate incorporating ducts and cells in a specified pattern, and dispenses with complex assembly operations in heat exchangers and skin cooling panels in supersonic aircraft. Hollow sheet incorporates ducts which run through the sheet for its entire length.

Advanced titanium extrusions, as well as titanium airframe and engine components, have been developed by **ICI Metals Division**. Beryllium and niobium are also being developed by the division.

The problem of kinetic heating has led to an impressive development in a non-metallic material. **Triplex Safety Glass** show a temperature-resistant windscreen laminated with silicone type K interlayer which will resist temperatures up to 150°C, while another line of attack on the same problem has produced an alumino-silicate glass.

**Formica** have considered every aspect of the material requirements for printed circuits, with the result that they have a range of products suited to every possible service condition. A copper cladding bonded to a base should show good dielectric properties combined with resistance to heat, shock and moisture, and should be amenable to a punching operating for production purposes. Formica can supply a grade of paper, fabric or glass fibre, all impregnated with resin, where a nice balance is achieved between the several properties. Examples of small assemblies are shown which are exceptionally compact and robust.

Small indium/bismuth primary cells which yield a good current output despite an astonishingly low weight are shown by **Metachemical Processes**. These withstand storage at 70°C, yet can be discharged down to −15°C. These are most impressive when handled, the heaviest being only 0.42oz in weight.

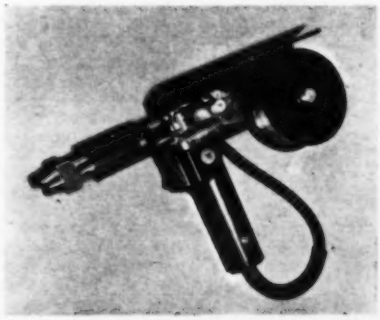
An important development in the reinforced plastics field is shown by **Fibreglass**, whose conical radomes wound direct from filament achieve maximum strength combined with the most logical method of manufacture. Roving or filament wetted with epoxide resins is wound directly to shape, chemical linking agents ensuring retention of a high proportion of the strength even after prolonged water immersion at elevated temperatures.

A new development in shielded-arc welding has been introduced by the **Rowen-Arc Division of Rubery Owen**. This is the Rowen-Gun, which is described as a gas-shielded metallic arc consumable electrode welder. The salient new feature is the weight of only 3½lb. The consumable electrode is carried as a reel on the gun, the speed of feed of the wire being automatically co-ordinated with the current supplied to the arc. Argon gas or carbon dioxide can be used as the shield. It has been found that carbon dioxide gives faster welding with mild steel due to the greater penetration of a steady arc to a greater depth than is possible with other welding techniques. This in turn means faster welding with less distortion. Samples of welds are shown to bear out these claims.

Turning to a forging process, **Firth-Derihon Stampings'** fine example of a 29in diameter turbine disc forging in Nimonic 90 weighs 525lb as a billet, but machines down to a disc of 468lb weight. Nimonic 90 is very difficult to forge, being designed to resist plastic flow at elevated temperatures, so that this was a striking example of skill in metal shaping.

*Metachemical Processes Ltd indium/bismuth primary cells*

*Rubery Owen Rowen-Arc welding gun with argon or carbon dioxide shielding*



*A large forging in Nimonic 90 by Firth-Derihon*

**Round the Stands . . .**

# GROUND EQUIPMENT

EVERY year it seems that there is a larger range of ground equipment competing for space in the outdoor equipment park. Certainly the space occupied by exhibits had increased this year, and there was less for casual perambulation.

Towering above all (in the absence, for the first time for many years, of Martin-Baker's ejection seat ground trainer) was a 42ft-high Britannia tail servicing platform built of **Dexion** slotted angle. With six servicing platforms arranged at three levels, and a built-in hoist to assist in the removal of the rudder, this wheel-mounted servicing tower was the most convincing proof yet seen of the structural stiffness that can be gained in bolted structures built of slotted angle. A crane gantry with a Bristol Olympus slung beneath it showed the capability of Dexion structures for load-bearing tasks, while four large storehouse racks built-up for a material cost of only £94 were visible proof of its good economics.

Alongside a Lycoming-engined Prospector exhibited by its associated company Lancashire Aircraft Corporation, **Samlesbury Engineering** had a bright yellow Cargoveyor—a specialized freight and baggage loading truck the company builds on a forward control Morris Commercial three-ton chassis. This has an elevating conveyor which lies alongside, and projects forward of the half-width driver's cab. The conveyor is raised and the belt driven hydraulically, the power coming from the vehicle's diesel engine. The conveyor can operate to any height between 15in and 11ft 6in from the ground, and when not in use is lowered and partially retracted, to reduce its projection ahead of the driver's cab. The Samlesbury-built van body behind has a capacity of 580 cu ft.

Baggage of an altogether bulkier kind is handled with the aid of **Shorts'** freight lift. Originally developed for use with the Britannia 253s which Shorts have built for RAF Transport Command, the lift is now commercially available. It can raise a maximum load of six tons to a height of 12ft—8,000lb can be raised to this height in about two minutes. It is powered by a 112V d.c. motor, which can be connected to the aircraft supply. The lift was designed to be air transportable, and itself weighs about 4,000lb. A team of six men can assemble it in about 20min and dismantle it for carriage by air in about ten.

**Houchin** showed two new ground power units, of 60kVA and 15kVA capacity. For the first time these units are completely valveless, silicon transistors being used throughout. The alternators are brushless and the lack of sparking obviates radio interference and makes maintenance easier. Direct current can be taken off either unit, for each has a transformer rectifier. The largest unit, 100 of which have been ordered for the Mk 2 V-bombers, has a continuous rating of 80kVA at 200V and 400c/s, or 60kVA at these figures and 10kW at 28.5V direct current. The smaller unit is being supplied to the RAAF for its Avon-Sabres, and has a rating of 15kVA and 3kW direct current at the same voltages. Pull-out control panels are fitted for ease of maintenance, and both units are mounted on sturdy chassis with independent rubber suspension. The 60kVA power unit has an A.E.C. 690 diesel engine and the smaller unit a Ford Zephyr petrol engine.

**H.M.L. Engineering's** exhibits supply power of another kind. This company showed its new Mk 5 hydraulic supply trolley, which can be obtained in electric, diesel and petrol versions, and which supplies hydraulic fluid at any rate up to 8gal/min and any pressure up to 4,000lb/sq in. Three have been acquired by BEA to service the new Vanguard fleet, and another unit is undergoing service trials at Boscombe. A smaller hydraulic supply trolley shown was the miniature hand-propelled unit being built for the Royal Navy. This is either petrol or electrically powered, and can supply up to one gallon a minute at 4,000lb/sq in.

Two static test consoles were also shown by H.M.L. One is for the testing of hydraulic and electro-hydraulic components, which normally supplies 5,000lb/sq in, but which can provide up to 10,000lb/sq in for static testing. The other console was a unit for testing Bloodhound launchers.

*Test console for Bristol Bloodhound launcher, by H.M.L. Engineering*

When it comes to aircraft servicing stands, **Morfax** have little to learn. Chief among the exhibits in size was a hydraulically operated elevating platform for building or stripping large gas turbine engines in the vertical position. The engine stands through a hole in the 10ft-square platform, which has a safe working load of 1,000lb. The front of the platform detaches to allow the engine to be removed. Men can work on and below the platform simultaneously.

**Gloster Aircraft** showed a prototype fire appliance built on a Land-Rover chassis, which the company has modified to forward control. This has achieved a more even distribution of load between the axles than that of conventional Land-Rover fire trucks. The new vehicle has a 150gal water tank, accommodation for a suction hose and ladder, and a Coventry Climax pump with a delivery rate of 350gal/min. The vehicle seats four.

Between its well-known Hertford 3,000gal refueller and the mammoth Super Seven 10,000gal refueller, **Zwicky** displayed a new hydrant dispenser, the Jetstream, built for Esso. This dispenser is designed to refuel Comet, Caravelle, 707, DC-8 and similar aircraft, working from a fixed-hydrant fuel supply. Mounted on a Bedford chassis, the dispenser pumps at a rate of 400gal/min at a pressure of 50lb/sq in through two circuits. Defuelling can also be performed, the appliance having a 40gal storage tank for this purpose. Zwicky also displayed a loading arm, for filling refuelling vehicles, which has meters incorporated at its base. Previously, these have always been mounted on the vehicles.

Liquid-oxygen systems are now becoming common in military aircraft, and civil transports—VC10, Argosy, D.H. Trident, to name but three—will soon be having these systems (for emergency oxygen also). **British Oxygen's** lox dispenser, now being built for the RAF and RN, has a wider context, therefore, than its immediate military purpose. The present small dispenser carries 75 litres of liquid oxygen—equivalent to about 2,500 cu ft of the gaseous variety, and can recharge the systems of about 15 fighter aircraft on one filling.

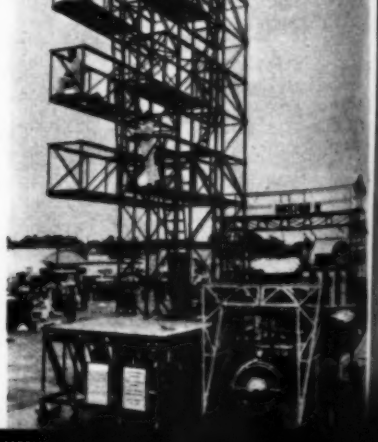
**H. W. Edghill**, who recently introduced a new range of mobile servicing stands, showed their new type 5, which has been supplied to BEA. This takes the form of a platform elevated by a lazy-tongs structure, operated through a hand pump. The maximum working height is 10ft, and the platform is built for loads of up to 1,000lb. Edghill also showed a wheel changing dolly for the Boeing 707, and which they are manufacturing to BOAC design.

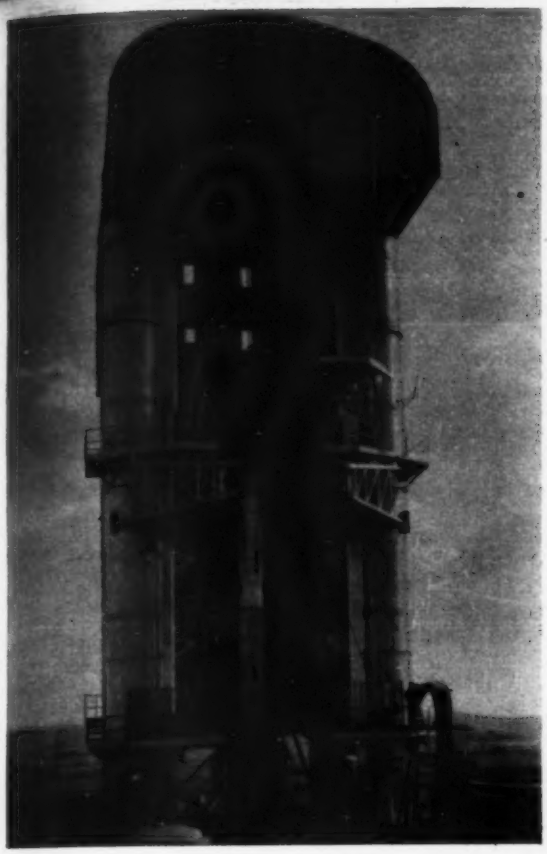
In the equipment park were a few items of missile ground equipment. The most notable of these was a transporter for four Firestreak air-to-air missiles, shown by **M. L. Aviation.** The missiles are carried on their own individual carriages, for wheeling under an aircraft wing, and these carriages are ramped up on to the transporter, and locked in position in tiered pairs. One man can load or unload the transporter without assistance.

*Pull-out control panel of one of the new Houchin ground power units*

*"Aircon" air-transportable container to house STC mobile CADF equipment (Airtech Ltd)*

*These exhibits illustrated typical uses of Dexion slotted angle in the aircraft industry*





*Test stand A1, with a Blue Streak (engineless) installed. The location of this stand can be determined from the drawing overleaf*

# SPADEADAM

## Space Springboard or White Elephant?

BY THE TECHNICAL EDITOR

LAST week we briefly reported the fact that on September 1 we were invited by the Ministry of Aviation to visit the Spadeadam Rocket Establishment. Planned solely for the task of conducting static tests on Blue Streak, the now-defunct British long-range ballistic missile, and in particular on its propulsion system, Spadeadam is by far the largest facility devoted to the development of large rocket engines outside the USA and Soviet Union. It is now permissible to elaborate on our earlier report and say a great deal about the Blue Streak propulsion system and the facilities available for testing it.

As a project Blue Streak was initiated in 1954, and it is said that the first manufacturing contracts were let to de Havilland Propellers Ltd—the prime contractor—the following year. From the outset it appeared logical to minimize development problems by leaning to a considerable degree upon work already accomplished in America. In the manufacture of the airframe the prime contractor and D.H. Aircraft established a working liaison with Convair Astronautics, while in the field of propulsion Rolls-Royce and the Rocketdyne Division of North American Aviation jointly announced in August 1955 a mutual technical-assistance agreement which was to run for ten years. These associations stemmed from the Wilson-Sandys Collaboration Agreement on guided missiles of June 12, 1954. It was largely this which made the concept of a large home-grown ballistic vehicle technologically and financially feasible to this country.

Facilities for the ground running of large liquid-propellant engines are exceedingly costly. The first people outside Germany and Russia to learn this vast field the hard way were Aerojet-General and Rocketdyne, and, although Blue Streak engines could have been shipped to Santa Susana or Neosho for testing, it was finally agreed to build an *ad hoc* facility in a lonely part of the United Kingdom. The surveyors chose the Fells of North East Cumberland at a place known as Spadeadam Waste. The Ministry of Supply (now Ministry of Aviation) reserved some 10,000 acres, determined what test facilities were required and approximately how they should be sited. A broad directive was then issued to the Ministry of Works, who investigated the terrain and subsoil, the interference between the various facilities while under construction or in operation and the scheduling so that each portion of the establishment could be occupied when it would be needed.

Main constructional contract was negotiated on a prime-cost basis with the successful tenderer, a consortium formed between BOC and Wimpey now registered as British Oxygen Wimpey Ltd. British Oxygen Engineering were given the task of building a liquid-oxygen production plant, while Pye Ltd have handled most of the instrumentation. Major subcontractors for instrumentation include New Electronic Products, SE Laboratories, Metrovick and Honeywell-Brown.

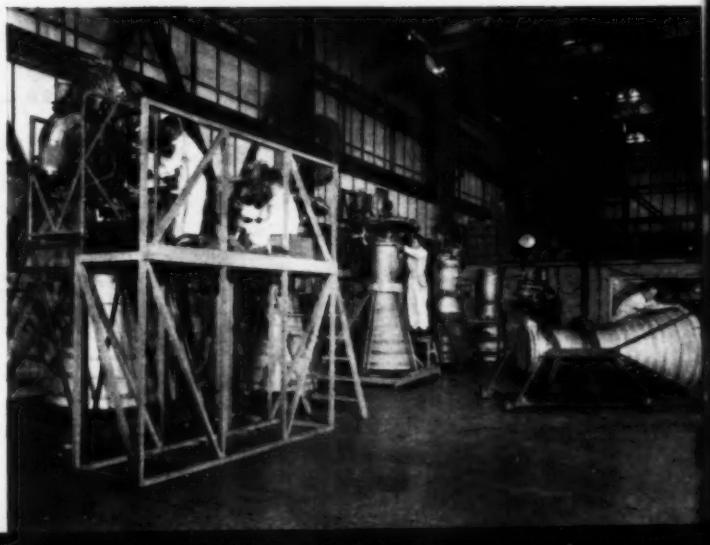
When construction started in January 1957 Spadeadam was truly a waste; there were no essential services of any kind and the builders even had to construct a road in order to bring in the labour force and the many thousands of tons of material—ranging from bulk cement to the most delicate instrumentation. Peak labour force was rather more than 2,000, largely housed in a hutted camp on the site. As the work progressed so did the estimated cost rise, and in June 1959 the total bill was placed at £20m, with the probability of future expenditure amounting to £5m. In the event, of course, Blue Streak was cancelled as a military weapon in April of this year, and the final Spadeadam configuration and budget are far from certain. In the succeeding text it is convenient to describe the SRE by discussing each of the five major areas in turn—as we saw them on our recent visit.

**Site F, Administration** As one approaches Spadeadam by road (and there is no other means of entry) one can see the large test stands from at least a dozen miles away; but the rough grazing land is hilly and hides them from time to time. The administration area is that part of the establishment first encountered, and it is here that most of the permanent staff work. The entire facility is managed on behalf of the Ministry of Aviation by Rolls-Royce Ltd, and it is their police who scrutinize the visitor's credentials.

As the drawing overleaf shows, the direct labour employed in building the SRE were housed partly in a hutted camp on the road which connects with the public highway further south. Further into the establishment is what is known as "Site F," which includes the administrative offices and all the laboratories and workshops required to support the rest of the establishment We started our tour in the engine fitting shop. Here we made our acquaintance with the RZ.2 and learnt something of its background.

The Rolls-Royce North American Aviation agreement required NAA's Rocketdyne Division to pass to the British company design and manufacturing information on large liquid-oxygen/hydrocarbon-fuel engines to assist the production of similar engines in Britain (conversely, Rolls-Royce compare notes with Rocketdyne).

Rocketdyne achieved a series of major technical advances in developing the 135,000lb boost engine for the now-defunct Navaho missile. From this engine stemmed the MA-2 (Atlas), MB-3 (Thor) and S-3 (Jupiter) families, which have since been developed into more advanced engines. In designing an engine for Blue Streak, Rolls-Royce did not attempt any state-of-the-art advances, but were content to use a thrust chamber essentially similar to those of the engines already mentioned (with the simplification of having a truly conical expansion nozzle instead of being bell-shaped). *(continued on page 477).*



*Rolls-Royce RZ-2 engines being assembled in the fitting shop. The RZ-2 is 127in high, weighs about 1,500lb and has a thrust of over 135,000lb at sea level on liquid oxygen and kerosine*

# SPADEADAM ROCKET ESTABLISHMENT

***No photograph can give a direct pictorial impression of the SRE, and accordingly our artist John Marsden has prepared this illustration. Even this is necessarily falsified, since if a true representation of the establishment were to be compressed into this page the individual installations would be too small to identify***

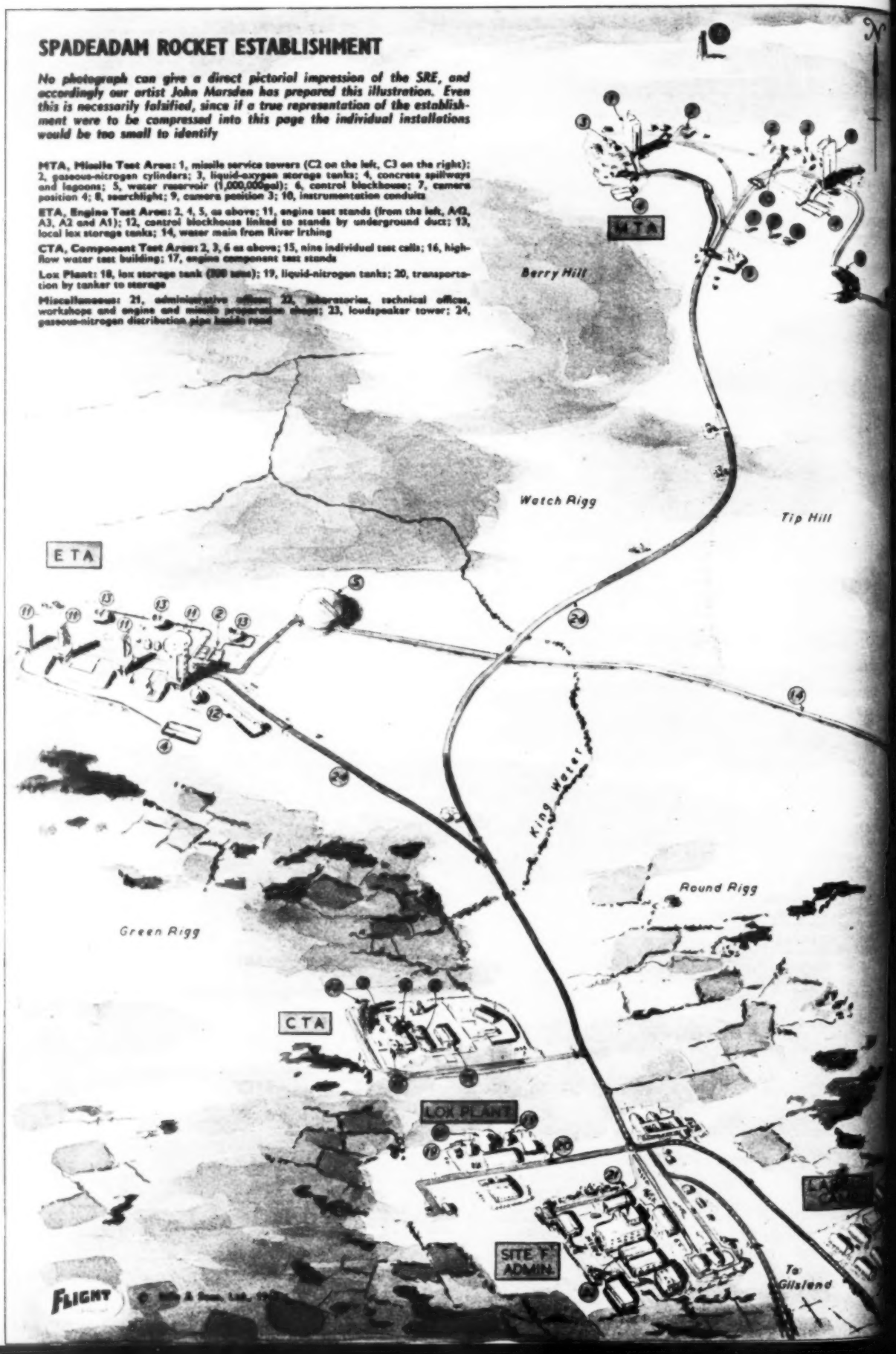
**MTA, Missile Test Area:** 1, missile service towers (C2 on the left, C3 on the right); 2, gaseous-nitrogen cylinders; 3, liquid-oxygen storage tanks; 4, concrete spillways and lagoons; 5, water reservoir (1,000,000gal); 6, control blockhouse; 7, camera position 4; 8, searchlight; 9, camera position 3; 10, instrumentation conduits

**ETA, Engine Test Area:** 2, 4, 5, as above; 11, engine test stands (from the left, A42, A3, A2 and A1); 12, control blockhouse linked to stands by underground duct; 13, local lox storage tanks; 14, water main from River Irthing

**CTA, Component Test Area:** 2, 3, 6 as above; 15, nine individual test cells; 16, high-flow water test building; 17, engine component test stands

**Lox Plant:** 18, lox storage tank (500 tons); 19, liquid-nitrogen tanks; 20, transportation by tanker to storage

**Miscellaneous:** 21, administrative offices; 22, laboratories, technical offices, workshops and engine and missile preparation shops; 23, loudspeaker tower; 24, gaseous-nitrogen distribution pipe beside road



XEROX

Each chamber is assembled from about 300 Nimonic tubes, brazed and welded together and secured against bursting by welded circumferential bands. Kerosine fuel is fed down alternate tubes to the end of the divergent section, returning along the intervening tubes to the injector plate in the head of the chamber. Above the chamber, and not directly attached to it, is the turbopump group. In the design of this large package of rotating machinery Rolls-Royce have produced a purely British system, although it is reminiscent of early Rocketdyne practice. Installed in the missile the gas generator and turbopump are bolted rigidly to the airframe, whereas the thrust chamber is mounted on gimbals and pivoted about both transverse axes by twin hydraulic actuators. To permit the chamber to gimbal freely the high-pressure lox and fuel pipes from the turbopump incorporate Powerflex bellows and flexible sections (which, unlike those in America, appear to be completely trouble-free).

The original RZ.1 was rated at 135,000lb at sea level on lox and DTD.2486 wide-cut fuel, and it ran for the first time in 1958 on the P.2 stand at the RAE/RPD Westcott. The production engine is the RZ.2, which has a slightly different configuration. Components are made at the Rolls-Royce factories at Shrewsbury (the former Sentinel works), Derby, Barnoldswick and Hucknall. They are delivered separately to the SRE and built up into powerplants in the engine fitting shop. A photograph shows engines being assembled on vertical stands of two types, one of which may be turned horizontally (on right of picture). The engines are handed left and right into an A pack and a B pack, which are brought together to provide the twin-engine powerplant for the Blue Streak.

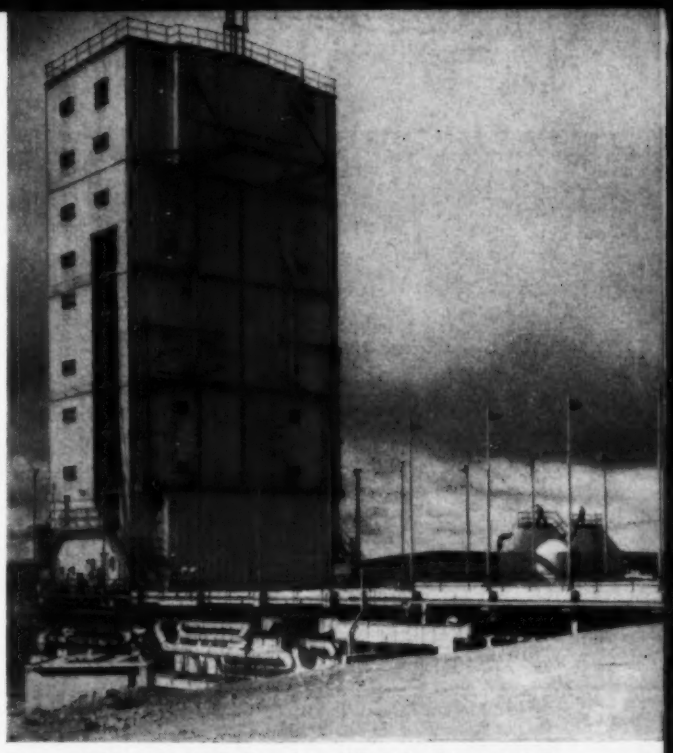
Leaving the engine fitting shop one passes through an instrumentation laboratory. Most of the work so far done at the SRE has been on development engines and the instrumentation for a complete powerplant frequently runs to well over 100 channels (an engine in full production might need to have only about 20 channels monitored during its checkout firings). Close by are a chemistry laboratory, wherein are studied means whereby the huge quantities of effluent from the test stands may be rendered innocuous to the local water supply, and a surprisingly large machine shop, fully equipped for really heavy engineering.

A short walk leads to the missile preparation area, to which complete Blue Streaks are brought by road from Stevenage or Hatfield for their initial checkout before going on to a stand. There are three bays in this spacious building, but only one is at present in use. In it was a Blue Streak airframe, providing the first occasion upon which our late LRBM could be inspected at close quarters. The body consists largely of propellant tankage, 10ft in diameter and about 50ft long. At top and bottom are added a tapered forebody carrying the re-entry vehicle and a skirt fairing around the rocket engines (there are no verniers). The airframe is fabricated from stainless sheet. Forebody and skirt are stiffened by axial corrugations, but the lox tank is made like that of an Atlas, and like the ICBM Blue Streak must be either pressurized or stretched to maintain its stability. The transporter in which the Blue Streak was lying was fabricated from rectangular and tubular steel sections, braced to sustain an end-load of 16,000lb. This force is generated by four hydraulic jacks arranged around the base of the forebody and pressurized at 363lb/sq in by a hand pump. The rearmost 25ft of body (much longer than the fuel tank which it contains) has a ribbed exterior, and a stencil warned of gaseous-nitrogen pressurization (for purging and valve operation).

Separated from the tankage, the propulsion skirt for this Blue Streak was supported in a rotating fixture and protected by a polythene cover as large as an average room. Ten spherical nitrogen bottles were hung on its exterior—"which," said our D.H. guide, "is as good a place as any."

A few minutes' drive leads to the liquid-oxygen factory run by British Oxygen Gases Ltd. At first-floor level are two complete plants, each with a daily output of 50 long tons of liquid oxygen (plus 60 tons of gaseous nitrogen and 8 tons of liquid nitrogen). At present one plant is shut down and the other never ceases operation. The principle employed is the familiar one of distilling the atmosphere. A 3,000 h.p. compressor feeds air to liquefaction machines, wherein the air is cooled and expanded to below its boiling point. The liquid is then pumped to a distillation column where the constituents are run off at different levels. The vital liquid oxygen is stored in a 500-ton tank, from which it is drawn off by road transporters. Nitrogen gasholders serve a pumping station which distributes the inert environment at 3,500lb/sq in to the operational portions of the establishment.

**Component Test Area** This is the next part of the SRE encountered by the visitor, and its purpose is to calibrate and test engine subassemblies prior to their incorporation into a powerplant. The CTA has nine concrete test cells arranged round a central blockhouse connected by instrumentation, TV, periscope and control linkages. Most of the cells have been stripped of their expensive equipment and are more-or-less mothballed. The largest building in the area is a water-test facility for the "cold" testing and calibration of turbopumps, thrust chambers and injector plates. Its capacity of 2,000gal/min at 950lb/sq in and 6,000 gal at 300lb/sq in is greater than that of any other test cell in Britain.



*Test stand C3 in the Missile Test Area. Off to the right, out of the picture, is C2, which is not yet quite complete; C3 is ready for use*

At the time of our visit a "boilerplate" Blue Streak propulsion system, mounted above a turbopump, was being subjected to lox recirculation tests. Although most of the system was heavily lagged, oxygen vapour was streaming from vents at various heights up to about 100ft. In the missile the two gas generators start independently, but a sequencing system shuts both down if either should fail to run up to speed within the specified time (perhaps of the order of 2sec). As might be expected, the unit operates on a fuel-rich mixture at 600°C, and the surplus kerosine burns noisily from a stack pipe (photograph last week). Elsewhere in the CTA is a cell where a pair of Avon RA.7 turbojets are geared to provide 14,000 s.h.p. to test turbopumps independently.

**Engine Test Area** Driving north from the facilities already visited the terrain becomes more bleak, and rises gently over Spadeadam Waste, on the south side of which is located the ETA. Here the individual propulsion units are tested in single or twinned form in four stands spaced about 250ft apart. Stand A1 is capable of accepting an entire missile, and is temporarily being employed in functions more properly reserved for the MTA. In it is a Morfax prototype launcher and the tower contains five platforms to provide access to the entire missile. This stand can be employed to ensure compatibility of all portions of the missile, but no engine has yet been fired in it.

Next comes Stand A2, wherein tests are run on complete Blue Streak powerplants. The 70-ton flame deflector bucket is cooled by water flowing at 24,000gal/min—too much for local streams; it is piped from the Irthing three miles away—and the effluent is collected in storage lagoons for processing. Above the engine under test is mounted an 11,000gal kerosine tank topped by a 16,000gal lox tank (in America it is common practice to put the fuel above the lox). Both propellants are pumped from local storage, the lox being fed from a pair of 100-ton lagged yellow tanks submerged partly below ground level. To prevent cavitation at the engine turbopump inlets the tanks are pressurized by nitrogen, fed from 3,000lb/sq in bottles served from the pipeline already mentioned.

Third of the stands is A3, which at the time of our visit was occupied by a single RZ.2 with its gimbal actuators replaced by rigid struts. Curiously, the local temperatures on the flame-bucket are much higher than the worst encountered on the twin-engine stand A2. The last of the stands is a novel erection of reinforced concrete, known as A42. Much less lofty than its neighbours—and built for the fraction of the cost—it carries its propellants on either side and may well become a future standard for such structures.

Some 600ft east of A1 is the control blockhouse for the entire ETA, built of 24in reinforced concrete and generally below local

*A Blue Streak on its transporter; the arrow points to one of the four jacks which stretch the airframe to prevent it from collapsing*

## SPADEADAM . . .

ground level. It is linked with the stands by an underground concrete duct 7ft square and 1,100ft long, within which are routed over 8,000 electrical cables. The blockhouse is equipped with optical and TV viewing arrangements, and each firing is recorded by remotely controlled cameras located all around the stands. Eight consoles control the engine under test and the instrumentation. Among the latter the chief installations are 130 pen/chart recorders and four 24-channel oscillographs.

Rolls-Royce counted-down a complete powerplant in A2 for our benefit, but owing to failure of the fuel pressure to reach the required value the two engines shut down after about 1.5sec, just as full thrust was reached. A special evaluation powerplant, this engine ran for 100sec later in the day to atone for its having ended a successful run of 30 firings. Altogether the RZ-2 has been fired about 300 times, 35 firings being on the complete double powerplant. Variation in the lox reference pressure enables the thrust to be controlled over a wide range, and reliability is outstanding. Controlled runs have been made from 2sec up to many minutes, and the engine is fairly regarded as a space-age Dart.

**Missile Test Area** Out in the wilds to the north, the MTA contains two test stands each capable of exploring every system —apart from the warhead—in the Blue Streak. Missiles are brought in on their transporters with engines attached. The tug pulls the missile on to the 300ft concrete causeway at the far end of which is located the stand. It then reverses the transporter against the link frame positioned on the causeway, provided with lugs which engage in trunnions on the launcher, and is finally disconnected. The transporter and missile are pulled up vertically by cables from the tower until the missile skirt engages with the hold-down claws on the launcher (*Flight* for March 11, page 329). Finally the transporter is lowered again, coupled up to the tug and driven off.

The complete tower weighs 450 tons and rests on four multi-wheel bogies driven by battery-fed motors. It is designed to withstand 80kt winds statically (about 40kt on the move), and when the checkout is complete is rolled away to the far end of the causeway. It may be of comfort to British readers to know that the launcher claws on these stands (C2 and C3) differ from the operational system in that they can be disengaged only by a laborious manual screwjack system, which certainly could not be reached while an engine was firing.

During a firing trial the complete stand area is evacuated, and the operation is controlled from a blockhouse 1,000ft away. Here again optical, episcope, TV and cine cameras are used to see what is going on, and the principal instrumentation (by D.H. Propellers and Metrovick, rather than by Pye) comprises 19 control consoles, 4 checkout consoles, 27 pen/chart recorders covering 216 channels and four types of magnetic-tape recorder with a total of 49 tape channels. Each stand is linked to the blockhouse by over 3,500 wires, the majority of which are run above ground in conduits which leap over the access roads via impressive bridges. It would be a pity if this place becomes redundant, just as it is nearing completion.

# A COMPLETELY NEW HISTORICAL ASSESSMENT

**The Aeroplane: An Historical Survey of its Origins and Development,** by Charles H. Gibbs-Smith. Her Majesty's Stationery Office, London. Price £1 15s. Illustrated.

ANY resemblance between this book and previous histories of flying is purely coincidental. After years of patient and fruitful research, Charles Gibbs-Smith has presented us with a completely new assessment of the worth and work of the pioneers —and presented is the correct term—for he has given it to the Science Museum as a successor to the late M. J. B. Davy's popular but out-dated *Historical Survey* of heavier-than-air aircraft.

A first indication of the extent to which we must revise our ideas on early history was given by Mr Gibbs-Smith's article entitled "Hops and Flights" in the April 3, 1959, issue of *Flight*. In this book the process is carried further. The author deals with the fame and claims of men like Stringfellow, Moore-Brabazon and Roe in a manner almost as merciless as that of Nasser's minions when they toppled the statue of de Lesseps from its plinth near the Suez Canal, although he expresses regret at having to do so.

In their places we have a number of new heroes. Cayley is revealed in his full greatness as the designer and builder of the first successful man-carrying glider. Félix Du Temple receives due credit for the first man-carrying powered aeroplane to make a "hop." Horatio Phillips goes on record as the first person to make a powered flight in the UK, in a device that looked more like a runner bean frame than an aeroplane. Only the Wright brothers seem to emerge with their traditional glory untarnished. Indeed, it is given a new sparkle by Mr Gibbs-Smith who adds to their achievements the first aeroplane flight with a passenger—an exploit formerly attributed mistakenly to Delagrange.

This brings us to our only adverse criticism of what is otherwise an altogether superb and invaluable work of reference. The author is so great an admirer of the Wrights that he persists in claiming that Orville's historic first flight on December 17, 1903, covered 470-600ft through the air, rather than 120ft over the ground, because it was made into a headwind.

Setting aside the obvious arguments against accepting flight "through the air" as the basis for measuring distances flown, its adoption in this context results from Mr Gibbs-Smith's stated belief that the Wrights "alone among the first pioneers deliberately flew into a wind." There is no proof that this is so. In fact, it would be strange if not one of the other pioneers pointed his aeroplane into wind, when small boys have known for centuries that a kite flies better when towed into wind.

At the other extreme, the author still does less than justice to A. V. Roe. He states that "the question of whether Roe's 'flights' of up to 180ft were aided by a downhill accelerated take-off must remain for ever unsolved." Yet "A. V." himself stated in February 1956 that "he would like it to be known that all his towing and flight trials were made on the level part of the finishing straight and not down the slope." To anyone who knew "A. V." this is the answer to Mr Gibbs-Smith's question. Certainly it is better evidence than a photograph which shows the 1908 Roe aeroplane on (not at the top of) the pull-up slope at Brooklands, minus engine, and which proves only that this was a good place to take a photograph. Circumstantial evidence is good enough to hang a man but not to form a basis for history!

However, there are few histories which are not tinged with the personal likes and dislikes of their authors, and those few are probably so bloodless that they are not worth reading. In this case, anyone who delves deeply into the book's 375 pages and 200,000 words will find hours of pleasure and a wealth of little-known detail. He will discover, for example, that an Englishman named M. P. W. Boulton invented a method of control identical with the modern aileron system in 1868. Had it not been overlooked, the history of the practical aeroplane would have been radically different, since it was the problem of achieving lateral stability and control that plagued the Wrights, Langley, Curtiss and the whole "European School" 30-40 years later.

Apart from its tremendous detail, the major quality of this book is its scrupulous accuracy of facts and figures. One can find a few minor slips. For example, the Snark missile is said to have ramjet power in the caption to the frontispiece, and the Short-Mayo Composite is credited with the first launching of one aeroplane from another, when this was in fact done 22 years earlier by the Porte Baby/Bristol Bullet "composite." But what does this matter? The small errors concern comparatively modern aviation, in which the author is not particularly interested. The all-important truth is that no author has ever before offered so many facts about the pioneer days of flight, or devoted so much time and effort to ensuring their reliability.

The glory of the book is that, apart from its worth as a work of reference, one can pick it up at odd moments and read something to suit all moods. There are three-and-a-half pages on the Rheims Flying Meeting of 1909, an article on "Bird Flight and the Man-Powered Aeroplane," a Chronology and Glossary, a delightful "First Eye-Witness Account of a Powered Aeroplane Flight" by the Wrights in 1904, and even a dissertation on the Earth's atmosphere. The happiest touch of all can be mentioned in the author's own words: "Between the History and the Commentary, I have placed an Interlude of prose and poetry to remind myself, and perhaps others, that the aeroplane was created and flown by devoted and intrepid men, working with no thought of reward, whose descendants are even now planning to pioneer the stars."

J. W. R. T.

# Straight and Level

As a matter of policy, I rarely publish any of the hundreds of letters that pour into my office. Some of them are so embarrassingly effusive that you wouldn't believe they were genuine anyway. Occasionally, however, I receive letters of criticism. One of these I now publish, as I know it will be contemptuously rejected by all those who visited the Straight and Level stand (No 6211) at Farnborough:—

Dear Sir,

I must protest in the strongest possible terms at the deplorably casual treatment I received on your stand at Farnborough. I wanted some information about a particular new product. For half an hour I was completely ignored. Eventually a nubile young woman in a bikini came up and told me that the person I wanted was asleep in the brochure cupboard. Infuriated, I forced the lock and found inside three men eating smoked salmon who likewise ignored me for several minutes. Eventually one of them said that the man I wanted was in the Straight and Level chalet—"if not, he's having an aspirin and water in the Scruggs chalet." At length I tracked him down at a Hunt Ball that was being held by Thinx Electronics at the Queen's Hotel. He did, I admit, try to help—in fact he spoke for an hour without telling me what I wanted to know. He eventually said that the information I needed was at the Wigan office, and I would be very welcome there at any time. So I drove straight to Wigan where I was told that, as a result of Straight's recent merger with Level, all information now had to come through the London office.

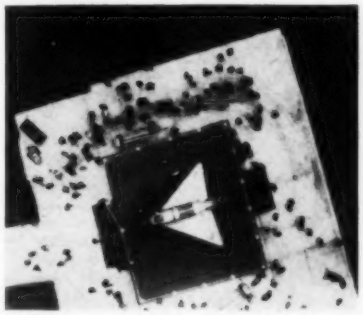
By this time I was losing patience, and you can imagine my feelings when on arrival at your London office I was told that the man with all the information was at Farnborough. Back there I found him, dressed as a South American air force general, trying to attract the attention of the young woman on Straight and Level's stand.

I am, sir, absolutely disgusted.

Yours faithfully.

● I have just been reading in the *Croydon Advertiser* about the first "flight" made in the borough—actually in the hamlet of Addington. The aeronaut was Sydney Sippé, who a few years later was to raid the Zeppelin sheds at Friedrichshafen in an Avro 504. The experiments were made in 1910, jointly by Sydney, his brother Arthur, and one James Jensen. After 50 years the details have been recorded for the first time, together with the claim that this aeroplane was the first in the world to be made of steel tubing—a claim which, I feel, would be difficult to substantiate.

But what pleased me especially in the story was the account of the actual attempt: "Sydney Sippé was thrown forward with some violence and his nose came into collision with one of the steel tubes. The nose came off worst, and a piece of flesh was removed from the inside of his thigh. That, with sundry bruises, was all. A well-meaning friend rushed up with a flask of whisky, which he thrust into the pilot's mouth, and so Sydney Sippé arrived home to his mother with a broken nose, a bleeding thigh—and slightly intoxicated."



"Flight" photograph

Buzzing with curiosity, workers and drones from other hives surround the visitor from Queen's Island, come to swarm in a Hampshire field: carefully guarded, and supplied with nourishment, she preens herself for hovering and vertical flight at the Society of Beekeepers' Annual Convention

● I hear that Lord Douglas has been asked by the Minister to investigate the possible advantages of a British Airport Corporation. The formation of such a body was recommended in the Bow Group's publication *Wings Over Westminster*. It is certainly time that some body such as this took responsibility for encouraging Britain's airports to pay their way. The extraordinary lack of financial control exercised by the Ministry, as revealed in the recent report of the Committee of Public Accounts, may otherwise continue to run up heavy bills for the taxpayer.

Now I hear that the Ministry are going to introduce a 3s 6d passenger service charge on UK domestic routes, and that they are going to put up UK airport landing fees—which are already among the highest in the world—for the second time in three years. I imagine that airlines who have read the report of the Committee of Public Accounts won't take too kindly to these methods of making our airports pay.

● *Near-Miss Quotation No 1:* "BEA cannot be satisfied with ATC facilities in the United Kingdom and overseas so long as the systems permit of near-miss incidents within controlled airspace, and the aircraft in a proportion of these incidents remain unidentified."—BEA's *Report and Accounts*.

● *Near-Miss (Possibly) Quotation No 2:* "Southern Air Traffic Control Centre does not wish to be told the whereabouts of private pilots crossing the London control zone in VMC. Position reporting of light aircraft under these conditions is an embarrassment which the centre would rather avoid."—A senior air traffic control officer as reported in *Flight*, August 19, page 272.

● Without the co-operation of pilots any noise-abatement programme is likely to fail, says Mr Tom Towers, who looks after Los Angeles noise abatement matters. He goes on:—

"Like any average individual, pilots like to be complimented on a job well done. The sincerely spoken 'good landing, captain' has never failed to bring an equally sincere 'thank you' in response. Pilots still take a great deal of understandable pride in executing a 'no-bounce' touchdown, even after accumulating 15-20,000 hours."

In other words, when they do a really good noise-abatement take-off, a thank-you from the right quarter wouldn't be amiss. LAP residents please note.

● "BOAC loaders at London Airport stopped work today to attend a meeting about a wage claim. Flights were held up and incoming services diverted to Gatwick. After the meeting loaders sat on chairs and on rails. 'We are on strike but we are not going to say why' was their only available comment."—*Reuter*.

ROGER BACON

Here's another solution to the airlines' problem of how to dispose of used piston-engined aircraft. Convert them into restaurants: someone has done so to this DC-3, as recorded by a "Flight" camera the other day in a park at Norrtalje in Sweden. Patrons sit on the wings or in the cabin. I've heard of an Anson being used as a children's playground in Papua, of two Solents being converted into a coffee bar, of a Rapide used as a bridge in, I think, Beirut, and of a Horsa glider in use as a greenhouse near Stony Stratford. Anyone know of other retired aeroplanes continuing to render services to the community?

*New mount for a Vulcan pilot of No 617 Sqn: Fg Off H. Hopkins giving a Chipmunk flight to Cdt R. Trigg of 181 Sqn, Air Training Corps, during the squadron's recent visit to RAF Scampton*

# SERVICE AVIATION

## *Air Force, Naval and Army Flying News*

### Director of Quartering

A NEW appointment has been announced for Gp Capt Frank Hume, who for most of his 24 years in the RAF has been a navigation specialist: from September 26, he is to be Director of Quartering at the Air Ministry, with the acting rank of air commodore. Since November 1957, he has been Senior Officer in charge of Administration at AHQ Malta.

### Lord Trophy Winners

COMPETED for annually by squadrons of RAF Transport Command as an efficiency award, the Lord Trophy has been won for 1960 by No 84 Sqn, which operates Beverleys at Khormaksar in the Arabian Protectorate: it was presented to them recently by AVM D. J. P. Lee, AOC Air Forces, Arabian Peninsula. The competition, which includes low-level flying, precision navigation and paratroop dropping, was held at Colerne earlier this year. No 84's winning crew were Flt Lt P. V. Mayall (capt), Fg Off C. H. Lansdell (co-pilot), Flt Lt P. J. Swatton (navigator), F/Sgt N. D. Simmons (signaller) and Sgt A. A. Newton (air quartermaster). Runners-up in the competition were No 30 Sqn, from RAF Eastleigh in Kenya, also an Arabian Peninsula Command unit.

### Fishermen find Lightning

THANKS to the chance discovery, by two weekend fishermen from King's Lynn, of the site where a Lightning went into the Wash on March 5, salvage operations are now being carried out to recover the whole of the aircraft and determine the cause of the accident.

The Lightning, from the Air Fighting Development Squadron at RAF Coltishall, came down into the sea after the pilot had ejected. A search for the aircraft was organized, but it was not until June 23 that any part of it was found, when a King's Lynn fishing vessel picked up a piece of tailplane. The actual position of the Lightning remained obscure until the weekend before last when Mr P. Tilbury and Mr K. Earley, garage proprietors from King's Lynn, discovered their net had been fouled by an obstruction when they were fishing three miles from Heacham. They hauled the net in and found pieces of metal in it; so they marked the spot and notified the Air Ministry. As a result, the salvage vessel *Airmoor II* has subsequently recovered most of the wreckage.

### P.531 in Battledress

A PRODUCTION order for "a substantial number" of P.531/2 Mk 1 helicopters for Army operations has been placed by the MoA with Westland Aircraft Ltd. This news follows the recent announcement of a development contract for this aircraft, a military version of the Wasp.

The P.531/2 Mk 1 (previously referred to as the Sprite) is a general-purpose five-six seat helicopter powered by an 885 s.h.p. Blackburn A.129 Nimbus free-turbine engine derated to 650 s.h.p. This derating enables sea-level performance to be maintained under all normal operating conditions.

Westland have said of the P.531/2 Mk 1 that its present design characteristics were achieved in complete liaison with, and in accordance with requirements of, the Services. The machine has a low silhouette and small dimensions, together with good all-round visibility resulting from the Perspex canopy extending from well forward to behind the passenger seating. The manufacturers add that these factors, in addition to its good manœuvring characteristics, "make it extremely suitable for reconnaissance and liaison duties."

### Remembering the Battle

IN a Battle of Britain Week appeal the chairman of the RAF Benevolent Fund council, Viscount Knollys, refers to those "for whom the Battle of Britain is not only a glorious memory . . . but an event which still casts a dark shadow across their lives—the shadow of a lost husband, father, son or of cruel disablement."

The fund, he says, exists to help those who suffer today because they—or a member of their family—gave life or limb at that critical time. For the past twelve years, this work of relieving distress has cost £1,600 a day, and money spent has exceeded income by £594,418. Viscount Knollys adds: "May I ask all, and not only those who remember the Battle of Britain, to express their gratitude for the past 20 years of freedom by sending a donation which will be gratefully acknowledged at 67 Portland Place, London W1."

### RAF Comet 4Cs

AS announced in our Farnborough Report issue last week (page 414), a contract is being negotiated by the MoA with de Havilland Aircraft Co Ltd for the purchase of five Comet 4Cs for Transport Command, which since 1956 has been operating ten Comet 2s in No 216 Sqn. The 4Cs, scheduled for delivery during next year and 1962, are powered by four Rolls-Royce Avon RA.29s of 10,500lb static thrust each. They combine features of both the Comet 4 and the 4B, having the former's greater wing span and larger fuel-tanks and the latter's longer, large-capacity fuselage. The 4C's cruising speed, at altitudes from 30,000ft to 39,000ft, is given as 500 m.p.h.; and it can fly a practical stage-length, with reserves, of over 3,300 miles. With 100 passengers and baggage the practical stage-length is 2,500 s.m.

### IN BRIEF

No 3 Ground Radio Servicing Sqn at RAF Norton, Sheffield, is to move to Huntingdonshire in 1962-63.

The RAF base at Kuala Lumpur, Malaya, is being handed-over to the Malayan Government next month.

No 85 Sqn, the Javelin FAW squadron which has been at West Malling since August 5 last year, moved last week to West Raynham.

Details of ski-ing holidays organized by the RAF Ski and Winter Sports Association may be obtained from Sqn Ldr D. E. K. Mock, Central Flying School, RAF Little Rissington, Cheltenham, Glos.

The first of ten Canadair CC-109 Cosmopolitans for Air Transport Command of the RCAF made its inaugural cargo flight from Ottawa to Goose Bay, Labrador, on August 17.

During Battle of Britain Week commemorations in Ottawa a Spitfire loaned to the RCAF has been on display at Parliament Hill. It is a Mk 16, TE353, which recently has been on display outside RAF Ternhill. When the Canadian Joint Staff in London advised the Air Ministry that the only Spitfire in Canada was a **Mk 2 in poor condition, the loan was readily** agreed to, in recognition of the major role played by RCAF pilots in the Battle of Britain; and TE353, a post-war aircraft built in 1946, was shipped to Canada.

*Capt G. D. Pound receiving on behalf of the wardroom of HMS "Osprey," parent establishment of the RN helicopter station at Portland, a silver model of a Whirlwind helicopter. The presentation was made by Mr E. C. Wheeldon, deputy chairman and managing director of Westland Aircraft, at Yeovil recently*

# The Thermals of Texas

BY PHILIP WILLS

LIKE every other sailplane pilot in the world, it has been my dream one day to come to grips with the legendary thermals of Texas. Last November I received out of the blue a letter from Gale Abels, an architect living in Boulder, Colorado, suggesting that, if I brought my Skylark to the 1960 US Nationals, he would buy it from me afterwards. I had no hesitation at all in accepting the offer.

Some nine months of fervid paperwork followed, since the Federal Aviation Agency by no means gives American gliding the freedoms which our British Gliding Association has won and retained in Britain. But finally, armed with my Private Pilot's (power) Licence, an ARB Certificate of Airworthiness, and an MoA Certificate of Registration allotting my Skylark (I hope not with intent) the most inappropriate letters G-ARBJ, my wife Kitty and I, the Skylark and trailer, Gale Abels and third crew-member Bob Morisey, all arrived together in the Morisey Chevrolet stationwagon in a raging thunderstorm at 2 a.m. on the morning of Monday, July 25, in Odessa, Texas. Here the championships were due to unroll themselves from August 2 through (as the Americans succinctly say) August 11.

Our hope was for a practice-week of spanking Texan weather, to enable us to go for a few records; and then for the contest days to include at least some sub-standard ones, to give the Skylark with its wide spectrum of performance a chance to beat the US super-heavies specially designed for the sole purpose of fast flying in strong conditions. But unfortunately, as it turned out, we got exactly the reverse: a week of very indifferent, almost cloudless, weak thermals, which on the day the contest started reverted to "normal" Texan streets of generous cumulus every day.

On Monday morning, however, we drove out to Ector County Airport (one of three in the Midland-Odessa area) and parked our trailer in the glaring sunlight. Al Parker came up, and in one minute we had made our first Texan friend. Al looks and behaves like one's idea of a typical Texan, and had undoubtedly borne the brunt of the local organization. He introduced us to his gigantic tug—a version of the wartime Harvard—which subsequently gave us the nearest approach to a rocket launch which I shall ever get, gave us a hangar to ourselves, and then we set off to investigate the nearby Motel. This proved to be practically the key to a successful trip, for without its air-conditioned comfort, its swimming pool, its handy restaurant and endless supply of ice-cubes I believe Kitty and I would not have been able to survive the overpowering heat and dust of each succeeding day.

We spent Monday settling in, finding out that British and US screw-threads are different and dry batteries have different dimensions, fixing our tow-rope, and so forth. Tuesday seemed a fair day, so I set off north on my eleventh 500km attempt, which proved once again that I can go over 480km almost anywhere, for I landed that distance from Odessa on a little airfield at Dumas, and we motored sadly home all night. The remaining days before August 2 were all cloudless and poor and, although I determinedly flew a number of 100km and 200km triangles, my times were nowhere near even the current British records. But at least I got to know the country.

The first thing to know about Texas is that it is flat—flat as your hat, flatter than that. The country slopes so imperceptibly up from the coast as one travels north-west from Houston that it is almost impossible to believe on reaching Odessa that it is some 3,000ft a.s.l.; but so it is. The next point to realize is that Odessa is the centre of the world's largest developed oilfield—16,000 wells (I think) within a radius of 100 miles. The outcome is that one flies over the exact picture of Alice-through-the-Looking-Glass, where the Red Queen takes Alice by the hand and, screaming "Faster, faster!" they fly over a chessboard, remaining exactly in the same place. For an oilfield is cut into squares by a series of dirt roads; at the intersection of each road a curious little machine, looking like a mechanical elephant, dunks away with its trunk in the ground, each dunk lifting several dollars' worth of oil into someone's pocket.

Apart from this chessboard, the country is mainly covered over large areas with mesquite, a species of low bush which would make for expensive landings, though the more watered areas produce endless large fields of corn, fallow or roots where landings are easy, though inhabited roads and telephones may be far away.

The country, therefore, is flat and brown and dark green and dusty, and over all blazes the sun. This really was a problem, for it affected one's efficiency, led to bad sunburn, gave us nightmares, and ruined the film in my camera when once I thoughtlessly left it on the ground for five minutes when it became too hot to hold in the naked hand. We learned to take salt tablets, how to operate our individual air-conditioning machine so that it did more than pump the used air round and round our bedroom, to wear a small wet towel on our head under our hat, not to move too fast, to put a wet towel over the perspex canopy until just before take-off, and not to touch any metal objects lying in the sun.

*"They fly over a chessboard . . ."*

We learned also that the local tarantulas, which appeared in their thousands the first night after the storm, but never again, are thought not to bite (though the appearance of a single one on me would have caused me to drop dead with fright); that, if you hear a rattlesnake rattling, you can't tell where he is, so the only thing to do is to walk carefully backwards in your own footsteps.

We learned further that it is erroneous to think that Americans and Britishers talk the same language, though with patience and goodwill ideas may be successfully exchanged. By the end of our visit Gale was picking the best root for us to take, instead of rowt, and we were talking of ships constructed of alloominum. One morning Kitty asked for a roll for breakfast, and was brought a kind of Chelsea Bun: on describing what she meant the waitress said, "Oh, you want a *biscuit*," and hurried off to return with a scone. We started putting gas into the petrol-tank. Honours were even and Anglo-US entente remained at top pitch.

By the evening of August 1 a total of 36 competing ships had arrived, two of them on spec because their pilots had not yet done the 300km Gold C flight which was an entry requirement. Both these heroes were rewarded by getting the distance in time to compete—such is Texas. Names I had known for years became real people, historic aircraft I had read about were there to touch and inspect. We were not amongst strangers, we knew as much about each other as do many daily friends.

The first day came, and we were given a 132-mile triangle, Odessa to Andrews Wink and return. The weather forecast was for cumulus—which we had so far hardly seen—from noon onwards. It was about a three-hour flight, and I selected 12.30 for take-off. This proved to be an hour and a quarter too soon and, as a result, although I arrived back first (to be met by a microphone from the local radio service) I only scored 15th, which was a bad start. I averaged 36.9 m.p.h., while Schreder on the HP-8 was first with 52.6 m.p.h.

*Three members of the US gliding community: Al Parker ("one's idea of a typical Texan"), Bill Ivans and E. H. Reeves*

## *The Thermals of Texas . . .*

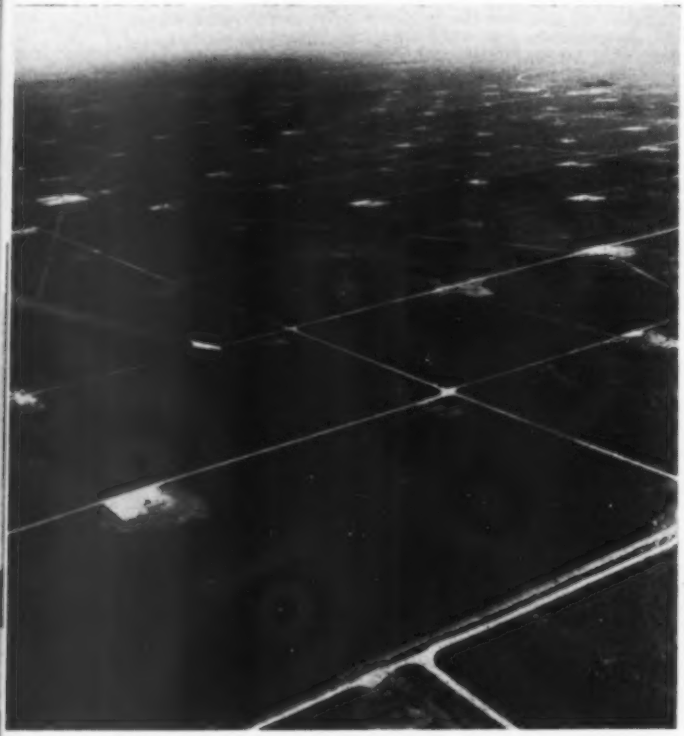
From now on the thing fell into pattern. Day after day the weather was exactly the same. The first tender cu appeared on the dot at 11 a.m., lift worked up to 1,000ft/min between 1 p.m. and 4 p.m. under a Rabelaisian sky, the clouds streeted at about 3 p.m., and lift faded between 6.30 and 7.30. Surface wind was strong; south-east, 20-24kt. Above 3,000ft (6,000ft a.s.l.) this became south-west, 10-15kt. It was too strong for record-breaking triangles.

We were not allowed to cloud-fly; indeed, to ensure this we were not allowed to carry gyro instruments at all, so that stability and handling qualities were relatively unimportant. There was, of course, no wave flying. In these circumstances nearly all the uncertainties of normal championship flying were removed, and the contest came down to nearly a straight comparison of the right-hand side of each sailplane's polar curve. And the daily and final results between the top bracket of pilots (who in such conditions could hardly make a serious mistake) clearly mirrored this.

There were two kinds of tests: short ones involving flying across the three or four central hours of the day, and long ones involving taking off as early as possible and landing as late as possible.

After this first day on which I started too early, I found my best take-off time for a short task was 1.45 p.m., whereas the heavy stuff took off around 2.15 and passed me on the way. My average speeds would be between 40 and 42 m.p.h., Schreder's between 49 and 52 m.p.h. Average rates of climb would be actually 650ft/min. From this someone could probably work out the relative points in our polar curves.

*". . . an oilfield is cut into squares by a series of dirt roads"*



On the long days, however, the position was more interesting, because I could get up to 45 minutes' start on the big stuff, and whisper on to a chance small field in the evening, whilst they would be sorely tempted to call it a day at the handiest airfield before the lift had entirely gone, to save themselves a dicey arrival amongst the mesquite and the rattlesnakes.

* * *

The second day's task was interesting: Odessa, west-south-west 73 miles to Pecos, return to Odessa, and then straight on as far as one could go. In fact a flight along a fixed course across wind, so arranged as to reduce retrieving mileage as much as possible. This was the stuff—I drew my course out as accurately as I could (but not accurately enough, because my final landing point, exactly on my line, lost me 6½ miles on the official line, which was not displayed at briefing) and took off at 10.45, a quarter of an hour before the first cumulus.

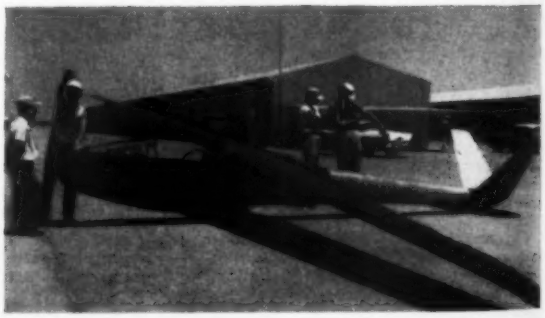
Odessa has another kindly aid to sailplane pilots, in the shape of several carbon-black plants which produce immense volumes of Stygian smoke. These very exactly show when the morning inversion breaks down, and also provide certain and hectic lift at all hours. There was little difficulty in keeping afloat on dry thermals and by 11.30, when the HP-8 and Co were in the air, I was 20 miles on my way.

Rather a long time ago I remember a story of the Babes in the Wood, who escaped from the forest into which they were lured by dropping a trail of white pebbles behind them. On the villain's third attempt they ran out of pebbles and used bread. The local wolf chased up and gobbled the bread and eventually the Babes —or have I got it mixed up?

Anyway, I now found myself in a similar situation, because as I plodded on and marked each succeeding thermal it was occupied by followers, so that by the time the wolves were airborne, they had a clear course to follow. I am of course exaggerating, but this is what it felt like! On this day, as on all the days, conditions rapidly improved and I flogged on across wind in a superficially empty sky until the turning point at Pecos, where the air suddenly seemed full of circling sailplanes. I then marked the ground signal, flew back to Odessa, and continued on to the east.

I had before take-off marked the 50km point on my projected line, as so often before in so many different countries, but not really thinking that even in Texan conditions one could exceed 50km across a 20-knot wind. Soon, however, I found I was averaging 50 m.p.h. for hour after hour across the flat country and, after seven hours in the air, covering 20, 40, 50, 50, 50, 50, and 40 miles, the long-awaited Diamond was clearly in sight. Lift was dying, but one last thermal to 7,000ft put the evasive jewel at last, at last, in the bag.

I landed after eight hours' flying at a small town called Haskells,



*SISU, one of the newest home-designed, home-built sailplanes taking part in the championships*

*Pilot/author and his ground-crew. From the right, Philip Wills, Kitty Wills, Gale Abels and Bob Morisey*

*"The clouds streeted at 3 p.m. . . ."*

after covering in all 329 miles, of which 322½ scored along the line. Schreder was a few miles farther on, with the Skylark lying second. This was pretty good in conditions of this kind. The only surprise of the day had been when Smith on his LO-150 came sailing by me in absolutely level flying, the Skylark doing 60kt and the LO at least five knots better. This was a machine with wings smoothed with micro-cell plastic, and the improvement this treatment brings about is undoubtedly tremendous, for Jensen's standard LO-150 which I met from time to time performed in relation to the Skylark no better than it should have done.

So—my Diamond was home, after a dozen tries in nearly as many countries. To make sure of it I did it again the next day. . . .

* * *

August 4 was really the major triumph of the task-setters, indeed one of the best tasks I have ever seen set. It was an out-and-return flight along almost the same track (without the first westerly leg) east to Stanford and return. If successful, this would be a world record, but in case anyone getting back should still be hungry for more, they could overfly Odessa and go on west, scornfully thumbing their noses at the FAI. In the event, this measured the day with micrometric precision, for two pilots (Schreder and Smith) got back, two (Carris on the RJ-5 and myself) missed it by one thermal (my speciality) and landed 18 miles short, and the rest of the field spotted the line back to the turning point.

The day could have been better than the one before from the weather point of view, because around 4 p.m. some cumulus built up into sweet little cunim, and if I had been able to use them there is no doubt that the Skylark, and some others, would have joined the HP-8 and LO-150 at Odessa. But in two consecutive days to do 329 and 328 miles on virtually the same course emphasizes the absence of uncertainties of weather or skill—one felt that an electronic pilot could have done the job just as well. However, they were two grand days I would not have missed for worlds although, having spent 15½ hours of the previous 32 in the Skylark cockpit, I almost endorsed John Randall and Fritz Sebek, both large and splendid airline pilots, who, as they hobbled out of the somewhat exiguous cockpits of their Ka-6s, said "Our pilots' association would not approve of this!"

* * *

After this triumph I regret to say the standard of task-setting deteriorated, for the age-old reason that it became distorted for non-contest reasons. The sponsors of the meeting were a body called the Chuck Wagon Gang, who were not at all what one might think, but a branch of the Odessa Chamber of Commerce, devoted to publicizing this remarkable city. In return for their support, for which naturally we were all most grateful, they had required an air display on the Sunday. This now caused the task setters to give us short and easy tasks on the next two sizzling days, so that we should be young and fresh when we came to don our spangled tights for Sunday.

Even in Texas the weather won't be mucked about like this and so, by the Monday and the longed-for Free Distance task, a giant front which had been hovering about up north during the week had descended to place a curtain within 200 miles of us. Free distance was I fear a disappointment, and as the front then continued south we only had one final short day. On short days we had almost reached the point where we could jot up the marks before take-off.

If these last sentences imply that by now I was bored, however, I have written badly. My own free-distance flight was so memorable that it must form the subject of a separate article [*To appear in a forthcoming issue—Ed*]. And even a plug-round on a short task in these sizzling conditions, to an Englishman with a variometer suffering from years of repression within the confines of English thermals, was as good as a course of psychoanalysis to a neurotic. I am simply saying that caviare is wonderful, but it is not a whole diet.

The final positions of the first 20 contestants were as follows:—

1, Schreder, HP-8, 6,945 points; 2, Carris, RJ-5, 6,516; 3, Smith, LO-150, 6,374; 4, Wills, Skylark 3f, 6,121; 5, Drew, Ka-6b, 6,095; 6, Oates, Skylark 3b, 5,883; 7, Coder, SISU, 5,852; 8, Moore, 1-21, 5,666; 9, Ivans, 1-29, 5,538; 10, Allemann, Ka-6cr, 5,534; 11, Thomson, Ka-6cr, 5,462; 12, Ryan, 1-23G, 5,435; 13, Compton, LK-10A, 5,114; 14, Yeates, 1-23H, 5,099; 15, Randall, Ka-6br, 5,095; 16, Coverdale, Ka-6br, 5,001; 17, Johnson, LK-10A, 4,901; 18, Sebek, Ka-6br, 4,695; 19, Starr, 1-23D, 4,630; 20, Mix, 1-23H, 4,586.

This pretty clearly reflects the relative performance of each glider flying in clear-air strong-thermal conditions. I would say that Drew (ex-Cambridge club) sneaked a place up by exceptional skill on his cleaned-up Ka-6; Coder, on the fantastic SISU, would have been higher if he had had more experience on this brand-new machine.

The accuracy with which one could assess relative performances was extraordinary. Oates on his Skylark 3b glided it out with me on my 3f over 20 miles. At 60kt my new tail produced without any doubt at all the pre-calculated advantage. More surprising, the famed RJ-5 and I glided it out one evening over 6,000ft and 30 miles: I started 200ft above and ended 300ft below Bernie Carris, and we landed together.

On several occasions prior to the last day I met Kit Drew's Ka-6 and could just beat it on the straight glide (my extra three metres span ensured of course that there was no serious argument with the standard Ka-6s). On the last day, however, due to cow-trouble on the Free Distance day, I was flying with one wing panel and half my rudder covered with untautened and nib-stitched fabric, ballooning in the most vulgar way for all the world like a be-buttoned cushion in the drawing-room of a fat mistress. On this day I could not hold Kit in straight flight.

This last flight consisted of a dash from one well-populated thermal to the next. In each I would climb up inside the SISU, which would come sailing past my flapping tail on the next glide, to be outclimbed again under the following cloud. We finished almost together.

(*concluded on p. 489*)

AIR COMMERCE (continued from page 449)

# Supersonic Implications

(from page 449)

The flight time advantage of a Mach 3 airliner on a 3,500 mile stage would be only 45min, assuming that for noise reasons both had to fly subsonically, perhaps for 700 miles, during climb and descent. On a medium stage of 1,000 miles, therefore, the time differential would amount to only 5min—"hardly enough to justify the use of a Mach 3 aircraft if its operating costs are higher." The report notes the "general opinion" is that it will not be worthwhile operating Mach 3 aeroplanes on stage lengths much less than 2,000 miles."

The report's specification of a Mach 3 aeroplane puts probable maximum take-off weight at about 350,000lb. The turbofan engine may well be the type adopted, perhaps with afterburning in the secondary airflow from the fan. Thrust/weight ratio of a Mach 3 airliner is likely to be the order of 0.3 to 0.4 and anything from four to eight engines of 40,000lb to 12,000lb thrust would be required. Essential performance of a Mach 3 airliner would be an operational range of 3,500 nautical miles (i.e., North Atlantic); a maximum take-off acceleration of 0.3g to 0.4g; a maximum subsonic rate of climb of 5,000-10,000ft/min; and holding and approach speeds not less than 90kt or more than 150kt. The report considers that landing speeds also should not exceed those of subsonic jets by more than a small amount.

Fuel would be similar to the kerosine-type fuels used in subsonic jets, but "better blended to have high temperature stability," since aerodynamic heating in the cruise will result in much higher fuel operating temperatures. At Mach 3, for instance, the outer skin temperature will be about 600°F (320°C), but so far as the possibility of doing without windows is concerned to increase structural integrity the report—echoed recently by Peter Masefield—says "it is doubtful whether this would be acceptable to the travelling public."

On the question of airworthiness the noteworthy point is made that "in many instances considerable work will be required to determine not only the airworthiness requirement itself but the procedure necessary to establish compliance with it."

**Supersonic airliner market** Evidently having heard the old joke about one traffic forecaster being unable to meet another without laughing, the report qualifies its estimate of future traffic growth with the warning that "it must be understood that these estimates might easily prove wide of the mark." Nevertheless, the study makes a thorough analysis of the likely growth, on which depends the size of the aircraft market. It is estimated that passenger traffic may double by 1967, expanding thereafter at least until 1975 at about five per cent per year. International traffic has a higher growth-rate than domestic traffic, and the proportion of traffic on stages suitable for supersonic airliners—which is taken to be 1,800 miles and over—is much greater in the international sector than the domestic—about 40 per cent and 10 per cent respectively in 1959. The international figure of 40 per cent could well increase to 60 per cent by 1967.

Having made its forecasts, and stated all its assumptions, the report concludes with the following estimate of the market *assuming that all suitable routes will be taken over by supersonic aircraft*. The number of aircraft needed to carry the potential traffic on all international and domestic stages over 1,800 miles are as follows:—

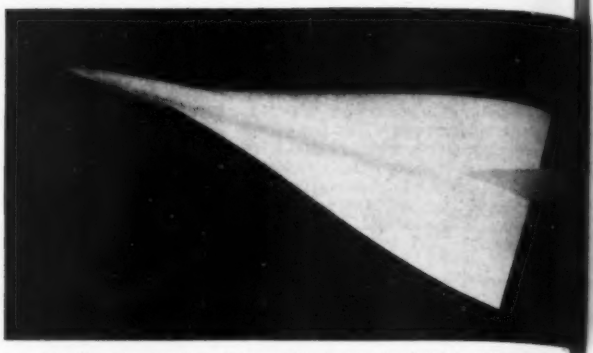
| | 1967 | 1970 | 1973 |
|---|---|---|---|
| Mach 3 (100-seat) ... ... | 125 | 159 | 202 |
| Mach 2 (100-seat) ... ... | 188 | 238 | 303 |

However, the report says that it would be preferable, "from the point of view of orderly development," that the number of new aircraft delivered should be no more than enough to provide the additional volume of air transportation required each year. It is then estimated that the number of supersonic airliners needed to supply capacity to cover traffic growth (and fleet losses) would be as follows:—

| | 1967 | 1970 | 1973 |
|---|---|---|---|
| Mach 3 (100-seat) ... ... | 42 | 49 | 51 |
| Mach 2 (100-seat) ... ... | 63 | 73 | 76 |

Of course, more aircraft would be sold if their economic range could be reduced. If, for example, they were economic down to 1,600 miles instead of 1,800 miles, 137 Mach 3 airliners would be required in 1967 instead of 125. Conversely, only 113 would be required instead of 125 if their economic range were 2,200 instead of 1,800 miles.

The report goes on to explore the possible market for a Mach 2 aircraft specially designed for the best possible operating costs on medium ranges, say 800 to 1,800 miles:—



*Handley Page's idea of a possible laminarized M2.2 airliner*

| | 1967 | 1970 | 1973 |
|---|---|---|---|
| Mach 2 (100-seat) ... ... | 240 | 270 | 307 |

**Supersonic economics** The ICAO study assumes a figure of $15 million (£5.35 million) as the price of a 100-seat Mach 3 aircraft; but it notes that if, to cover development costs estimated at anything up to £350 million, first costs were increased from £5.3 million to £9 million, then operating cost would go up by 10 per cent (due to a 66 per cent increase in depreciation, an item which is taken to be about 16 per cent of total operating cost). This, the report says, "might render the aircraft uneconomic to operate." The report notes that it is generally assumed that development costs "will need to be mostly provided from governmental sources"—in which case governments could decide how much development costs should be repaid.

The report comes up with the following operating cost estimates for a Mach 3 100-seat airliner: 1.2d direct, and 2.4d total (direct + indirect). Cost level of a Mach 2 100-seat aircraft might be about 10 per cent less on the same stage lengths. Assuming a revenue rate of 4.1d per passenger-mile, the Mach 3 aircraft would be able to earn about £5.4 million a year—an earning power of the same order as its purchase price, "which would make it comparable in this respect with most other aircraft." The earning power of a Mach 2 aircraft would be about two-thirds that of the Mach 3, "which would give it a better relationship between earning power and purchase price if purchase price were less than two-thirds that of a Mach 3 aircraft."

The revenue rate noted above, i.e., 4.1d per passenger-mile, assumes a 20 per cent drop in the average price of world air transport in 1959-67. Thus the operating cost figures will have to be at the level suggested in order that supersonic airliners should be competitive with subsonic jets. A supersonic airliner might be competitive if unit costs and hence fares were 10 per cent higher; but if the difference in cost were more than 10 per cent "the market for supersonic transportation would be seriously reduced and might be limited to the relatively small field of first and luxury class passengers."

There will certainly be some economic disturbance due to the change-over [to supersonics], says the report, and it may be expected that some airlines will have the same sort of economic problems as they have had with the introduction of other types of aircraft." Indeed, governments may expect that in some cases the transition to supersonics "will cause renewed requirements for subsidy or support of other kinds, including protective measures for some of their airlines."

**Cheap fares** The report does not think that the speed and time-saving of supersonic jets will create "a permanent new market for air transport such as might be created, for example, by reducing fares" by substantial amounts. It is possible, indeed, that "aircraft might soon be made available that could result in world air fares being reduced to less than half their present levels." This might produce a situation in which a supersonic airliner might be unable to compete, since its operating cost would be too high; thus a decision to develop a supersonic airliner "might in effect be also a decision not to take the steps necessary to produce a general reduction in international air fares." If the decision to develop and introduce supersonic airliners before 1975 meant that the general introduction of greatly cheaper air fares was delayed or abandoned, "this would be a consequence of economic and social importance for a large section of the world's population."

Obviously competition from airliners with very low operating cost, as the report points out, "is restricted by the present airline rate-making machinery." This difficulty might, the authors suggest, be overcome by some special agreement between the airlines—"but it would need government support and there are

## AIR COMMERCE . . .

probably only a limited number of routes where all concerned would be in agreement."

**Timing** The earliest date of availability of a supersonic aeroplane for commercial introduction is considered to depend on the cruising speed. If the speed does not exceed about Mach 2.3, conventional light alloys could be used in the structure, and the earliest date considered technically feasible is 1967 or 1968. For higher cruising speeds, stainless steel or titanium alloys would have to be used and the development would take longer. For cruising speeds of about Mach 3 the earliest date considered technically feasible is 1970. Aeroplanes with substantially higher cruising speeds, or with VTOL, could probably not be made available within the period ending about 1975.

But the report notes that few if any of the ground facilities and services required could be functioning smoothly before 1970. The earliest date considered technically feasible for the actual introduction into service of any supersonic airliner would, therefore, be 1970.

**Footnote:** On one point, the report notes, governments are unanimous: the supersonic airliner must be able to use existing runways.

## BREVITIES

A repeat order for three Avro 748s was last week announced by BKS, increasing the independent's order from two to five aircraft. Value of the contract is about £750,000.

By the end of 1961, estimates Sir William Hildred, director general of IATA, there will be a surplus in the airline industry of anywhere from 1,200 to 1,800 piston-engined aircraft.

Slick has signed its contract with Canadair for the purchase of two CL-44Ds costing $11.2 million (£4 million). A deposit of about £785,000 has been paid, the balance being payable over five years after delivery.

A DC-6 of Aerolineas Argentinas, one of five owned by the airline, crashed near Salto, Uruguay, on September 7, during a flight from Asuncion to Buenos Aires. All the occupants, 24 passengers and crew of six, lost their lives.

Sabena is to increase its fleet of four Caravelle 6s (Rolls-Royce Ra.29/6 Mk 531s) to six. Delivery will be made early in 1961. Price quoted is just over £1 million each.

The first resale anywhere of a DC-7C is likely to be made by SAS and Swissair. Riddle are negotiating for the purchase of three DC-7Cs, with an option on four others. They will be converted to passenger-cargo configuration for use on transatlantic MATS charters. Delivery would be completed by December this year.

BOAC is offering 30 apprenticeships in its sales organization to boys aged 17 and over. The corporation plans to engage 15 boys now and 15 on March 1 next. Three years' paid training in London will cover BOAC sales aspects in general and passenger reservation activities in particular. Inquiries should be addressed to the personnel manager at London Airport.

Due to arrive in London yesterday for talks with the Ministry of Aviation about the Anglo-Japanese air agreement were Sakabumi Imai, director of the Japanese CAB, and Yoichi Hayashi, head of the international section of the same authority. They will be accompanied by representatives of JAL, who are expected to inaugurate services to Europe in May 1961. The Japanese delegation will also visit West Germany from September 26-October 10 to discuss the bilateral agreement with that country.

According to a US source, Eastern Air Lines has asked Boeing for quotations on the Boeing 727 short-range jet with two alternative powerplants: the Allison ARB.963 of 12,750lb thrust (US licence-built development of the Rolls-Royce RB.163), and the P. & W. JT3D-1 turbofan of 14,000lb (powerplant of the Boeing 720B). Boeing are said to be prepared to undertake 727 production with orders for about 100 aircraft; United Air Lines have already signified their intention of purchasing 40. Take-off weight of this 68-seater (first-class) project is being quoted at 138,000lb.

A DC-4 of Trek Airways made a forced landing in the desert near El Badari, about 190 miles south of Cairo, on September 3. Fire was reported in No 2 engine whilst the aircraft was over the Nile. The aircraft was *en route* from Luxembourg to Johannesburg and had taken off from Cairo. Capt Ian Laatz, the commander, reported that the aircraft was destroyed but that none of the 64 passengers or crew of seven sustained more than cuts and bruises. (An article about Trek's very low fare services between South Africa and Europe appeared in *Flight* for March 4, pages 303-305.)

# *Missiles and Spaceflight*

## NUCLEAR POWER FOR SPACE

THREE nuclear-reactor space electric power units are under development by the US Atomic Energy Commission for the US Air Force and the National Aeronautics and Space Administration. The electric output of these three systems extends over the power range of 300 watts to 35kW.

The three systems include the SNAP 10 power unit, which is a demonstration system that utilizes thermoelectric power-conversion. The system covers the sub-kilowatt region of power and has no moving parts. Its extreme simplicity is said to provide the assurance of obtaining remote orbital start-up, high reliability, and long endurance. The reactor is controlled by the strong inherent negative temperature and power coefficient of reactivity.

The next power system is SNAP 2 which utilizes a similar compact nuclear reactor, weighing about 200lb, which is cooled with liquid NaK alloy and coupled to a small mercury vapour turbine-alternator power-conversion system. This system has a 3,000-watt output with one turbine system; future extension would permit the use of two power-conversion systems with one reactor for a total power output of up to 6,000 watts. This system will be provided with a thermo-mechanical reactor control system for increased endurance and reliability. The power-conversion system utilizes only one moving part, a combined rotating shaft suspended on liquid mercury bearings and rotating at 40,000 r.p.m. The SNAP 2 system at 3,000 watts will weigh about 600lb; at 6,000 watts output it will weigh about 900lb.

The third system, designated SNAP 8, is a direct outgrowth of the SNAP 2 powerplant development and will deliver 35kW with one mercury vapour turbine-alternator system. It will deliver 70kW with two power-conversion systems coupled with the same SNAP 8 reactor. The National Aeronautics and Space Administration is responsible for the development of the mercury power-conversion system for SNAP 8. This system will weigh about 1,400lb at 35kW, and about 2,500lb at 70kW.

Details of these three power units were described last month by J. R. Wetch and H. M. Dieckamp of Atomics International and Lt-Col G. M. Anderson of the US Atomic Energy Commission in their paper *Practical Application of Space Nuclear Power in the 1960s* before the International Astronautical Congress in Stockholm.

Dependent upon the type of payload and the spacecraft configuration, the paper indicated, the weight of radiation shielding might vary from less than 110lb for some electronic payloads to over 2,000lb for certain manned payloads. During the 1960-70 decade these SNAP systems would become fully qualified and, according to the authors, would be the predominant and most reliable source of high power available for application in space satellites. "In addition to electric propulsion demonstrations and planetary probe auxiliary power, the SNAP family of nuclear powerplants can, within this decade, extend our current 'exploration of space' activity to one of 'utilization of space.'"

Current estimates as to where various electrical energy sources were appropriate, based upon weight considerations, were presented (Fig 1). The only practical energy sources for long-lived spacecraft depended upon solar radiation, nuclear fission, or radionuclide decay. Radio-isotopes, under development for the AEC by the Martin Company, and solar cells, under development by the Air Force and by NASA, were attractive for small power requirements. At higher powers these systems became excessively heavy, expensive, and difficult to handle and to integrate into the spacecraft.

From standpoints of weight and cost, the solar mirror collector or the nuclear fission reactor coupled with thermoelectric, turbo-electric, or thermionic conversion systems were attractive as power sources. The solar mirror had yet to be proven feasible and practical as a power source because of the effect of micrometeorites on reflecting optical surfaces, and because of its need for continuous accurate orientation toward the sun. For the generation of powers greater than 10-30kW, the solar mirror collector became more impractical because of the difficulty in packaging such large collectors within the spacecraft currently under development.

The three specific systems under development must meet the requirements indicated in this table:—

| | SNAP 10 | SNAP 2 | SNAP 8 |
|---|---|---|---|
| Net electrical power ... ... ... | 300W | 3,000W | 35,000W |
| System weight unshielded ... ... | 300lb | 600lb | 1,500lb |
| Minimum system life ... ... ... | 1-3 yrs | 1 yr | 1 yr |
| Cycle heat rejection area ... ... | 10 sq ft | 110 sq ft | 400 sq ft |
| Availability ... ... ... ... | 1963 | 1964 | 1965 |

Turning to SNAP spacecraft integration, the authors pointed out that structural scatter of nuclear radiation from the reactor could cause a high payload dose if shielding for the scattered radiation was not used. Thus, if the reactor was located in the spacecraft nose and the nose-cone skin was jettisoned, and if the

## Missiles and Spaceflight . . .

radiator and payload were extended back behind the reactor and shield within the shadow of the shield, a minimum shield would result. With a conventional transistorized payload of any practical volume, the shield weight would be reduced to about 300lb.

The possibility of nestling the payload within the radiator cone during ascent existed in this layout. Placing the reactor-shield combination at the tip of the spacecraft increased gravitational restoring torques for satellite applications but could perturb the spacecraft flight stability. Re-entry burn-up of the reactor was more easily obtained with the exposed nose location.

It could be shown that the payload radiation tolerance affected the shield weight a great deal. Preliminary irradiations indicated that a conventional payload utilizing transistors might be subjected to $10^7$ roentgens of gammas and $10^{12}$ nvt of fast neutrons and would still operate satisfactorily. A payload especially designed for SNAP would utilize vacuum tubes or radiation resistant transistors in specially designed circuits which were tolerant of component drifts. Such a payload could be expected to withstand more than $10^{14}$ nvt and $10^9$ roentgens.

Extremely radiation-sensitive payloads, such as photographic film, should be equipped with individual shields so as to raise their tolerance to the payload design value.

Van Allen and cosmic-radiation sources were usually no problem for unmanned systems. Exceptions occurred in the case of photographic film, solar cells, and a few other very sensitive components. The yearly dose in the inner Van Allen belt (at about 2,000 miles) was of the order of $10^5$ roentgens. That in the outer belt (about 13,000 miles) was higher but was also more easily shielded.

The requirements for manned applications depended heavily upon mission and upon the spacecraft arrangement. If the mission was to spend much time in the Van Allen belts, the crew compartment must be shielded and, as a result, the reactor shielding might not be significantly greater than for electronic payload missions. If Van Allen radiation was to be by-passed, the crew compartment shield might be quite light and reactor shielding would increase. Normally, a configuration such as that illustrated (Fig 2) would be used with the crew compartment extended well to the rear of the SNAP. This not only provided the geometric inverse square reduction in dose rates but, more important, reduced the cone angle that the shadow shield must cover. The design was optimized when the incremental reduction in shield weight was offset by the incremental increase in telescope extension members and electrical conductor weights.

The SNAP 2 radiator would operate at 600°F; it might therefore be undesirable to have any payload components nearby. In a configuration such as shown in Fig 2, a payload package might be carried to orbit nestled within the radiator, and then extended prior to SNAP start-up. This eliminated temperature interactions and significantly reduced shield weight.

Since a more reliable SNAP could be developed if it operated at constant electrical load, and since induced torques were minimized under this condition, it was desirable to provide a dummy load control which insured a constant load to SNAP. It was necessary that payload transients be integrated into the design of the parasitic load control although serious interactions were not likely.

In the case of an Earth satellite, the axis of the combined rotating unit would normally establish the pitch axis of the spacecraft. It therefore would be necessary to have a very accurate alignment between the combined rotating unit and the spacecraft. Allowable deviations in spacecraft attitude would be reflected as

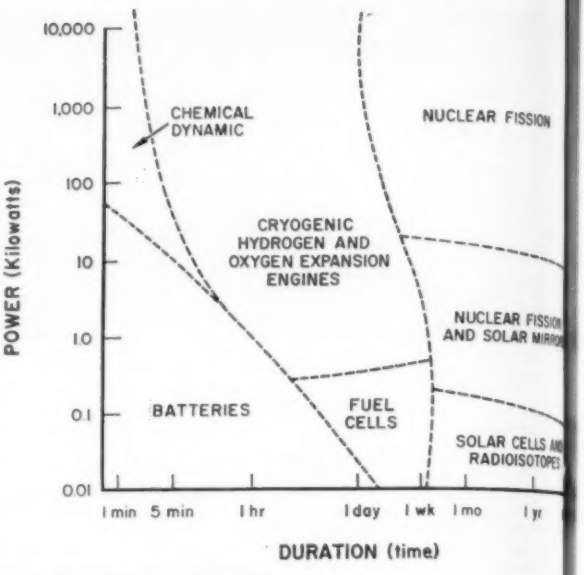



*Fig 1. Estimated space operations*

r.p.m. deviation tolerances on the combined rotating unit and an allowable torques resulting from other angular momentums in the spacecraft. At low altitudes, it might be feasible to obtain attitude control from natural restoring torques and an oscillation damper. At high altitudes, a dynamic attitude control would be necessary.

The SNAP 2 with the combined rotating unit aligned to the spacecraft pitch axis system had the following characteristics influencing attitude stability:—

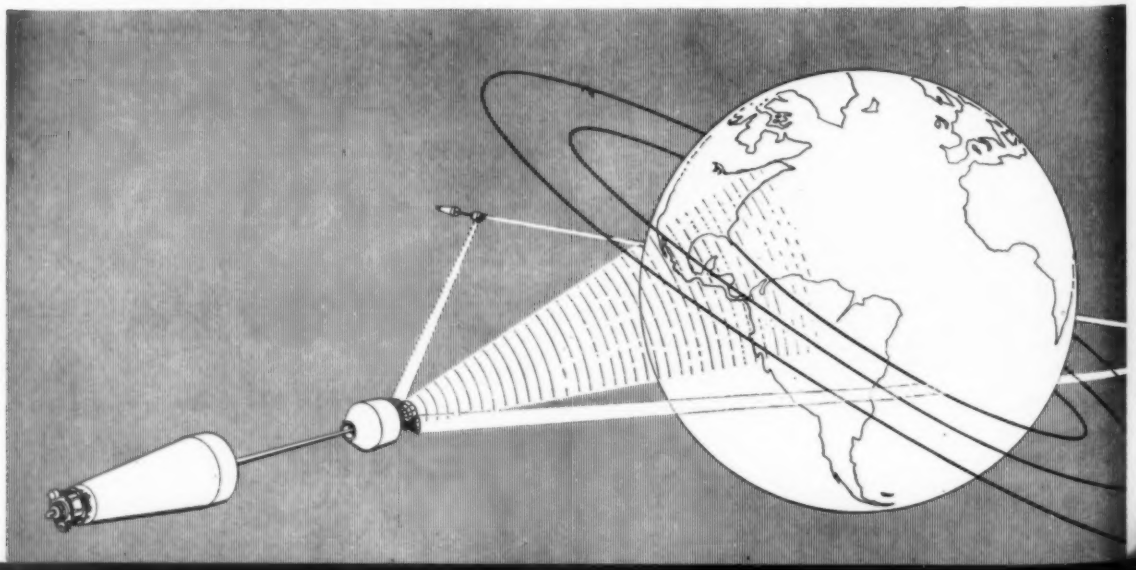
| | |
|---|---|
| Moment of inertia of combined rotating unit ... ... ... ... ... | 0.00072ft/lb/sec² |
| Roll axis angular momentum ... ... | <0.01ft/lb/sec |
| Pitch axis angular momentum ... ... | 3.00ft/lb/sec |
| Yaw axis angular momentum ... ... | <0.20ft/lb/sec |

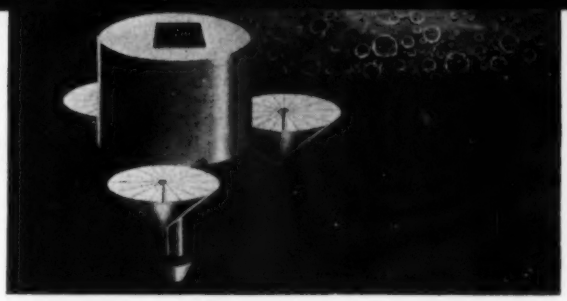
A speed drift of 1 per cent per year of the turbine alternator shaft corresponded to a torque of $9.7 \times 10^{-10}$ft/lb. A shaft acceleration of 1 radian/sec² corresponded to $7.2 \times 10^{-4}$ft/lb of torque.

All questions regarding public safety during the launch phase, the authors stated, could be satisfactorily answered by starting the nuclear reactor up when it had achieved a safe and stable orbit and the flight path and orbital life had been established. Thus all SNAP systems were being designed for orbital start-up.

Although re-entry from high orbits after a year's operation was not a serious problem, the SNAP units were being designed to burn up and disperse on re-entry above 100,000ft in order not to restrict their usefulness and operating altitudes. Analysis and arc-plasma jet simulated re-entry heating experiments had indicated that burn-up should occur above 200,000ft. Future tests might include actual re-entry tests of non-activated specimens to confirm these studies. Ballistic missile trajectories would be used in these tests.

*Fig 2. SNAP communication satellite (payload extended)*





*The Heliodyne, suggested by Northrop. A simple deep-space probe (pictured near the Moon) it would be powered in cruising flight by hydrogen held at 2atm pressure in a tank holding 800kg. A variable throttle controls the outlet through fine tubes heated in solar mirrors to provide high-velocity jets; the instrumentation would be carried on the pylon structure*

## SPACE-LAW INSTITUTE IN BUSINESS

The proposed statutes of the International Institute of Space Law, formed to succeed the Permanent Legal Committee of the International Astronautical Federation, were approved by the IAF Council at last month's Stockholm congress. The main aims of the Institute are: (1) to provide advice as requested to the IAF president, (2) to carry out such other tasks which may be considered desirable for fostering the social science aspects of astronautics, space travel and space exploration, (3) to publish proceedings and reports and a periodical journal, (4) to make awards, and (5) to hold meetings and colloquia on juridical and sociological aspects of the social science and to make studies and reports.

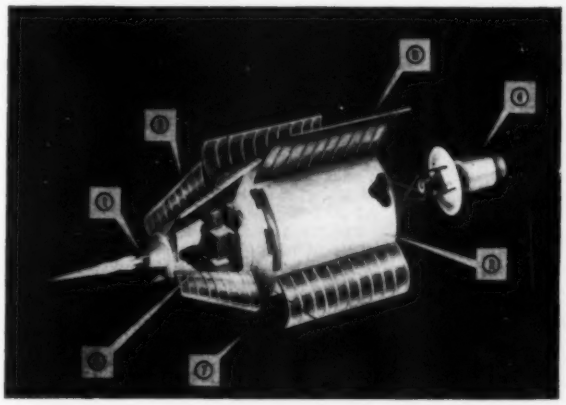
The IAF has eleven working groups at present studying specialized aspects of space law, with members chosen from the former legal committee. Group chairmen and subjects are: (1) John Cobb Cooper, eight problems including the delineation of airspace and outer space, State sovereignty, legal status of space vehicles and outer space; (2) Prof Alfred Verdross, definitions in space law; (3) Dr Michel Smirnoff, sovereignty on celestial bodies, legal status of Sun and planets, property rights in celestial bodies; (4) Mario Matteucci, effects on domestic law of new problems of space law; (5) Christopher Shawcross, regulation of space flights, registration, traffic rules, safety, etc; (6) Dr Eugène Pepin, international organizations which will have authority on outer space; (7) Andrew G. Haley, radio frequencies in space and collaboration with International Telecommunication Union; (8) Dr Robert Homberg, effects of space activities on private rights in such areas as nationality, citizenship, customs, domicile, crimes, immigration, emigration, ownership of property, torts and contracts; (9) Spencer M. Beresford, responsibility for damages by space activities; (10) international organizations; and (11) possibilities of concluding international space-law agreements, including an international space-navigation code analogous to the International Code of Signals on the High Seas.

At present, Soviet representatives have declined to participate actively in the affairs of the Institute or of the working groups.

## GROWING US SPACE BUSINESS

Conscious of the magnitude of the task involved in their entry to space on what is already a very broad front, the National Aeronautics and Space Administration are devoting a great deal of effort to systems management, co-ordination of effort and the optimum distribution of work between NASA and industry. In the coming fiscal year (which started last July 1) the administration's budgets for launch vehicles and spaceflight respectively amount to $403,023,500 and $370,132,000; and a considerable proportion of the total will be farmed out to industry.

One of the results of the lengthening lead-time on major space projects has been to dampen enthusiasm for all first-generation ideas, and place proportionately greater effort on the far more capable spacecraft which are now technically feasible and which are in no way compromised by any direct relationship with military weapons. NASA has sponsored a series of conferences with industrial firms to brief them on possible future business and on what will be required of them. The first briefing was held at the administration's HQ in Washington to give companies an overall picture. The second was held earlier this month at the Goddard Space Flight Center, where it was announced that this division's $221,500,000 space-vehicle budget for FY 61 will be divided in the ratio of 15 per cent "in house" and 85 per cent industry. Already the research and development effort applied directly to spaceflight is on a huge scale, and NASA has now made it clear that private industry is going to do most of it.



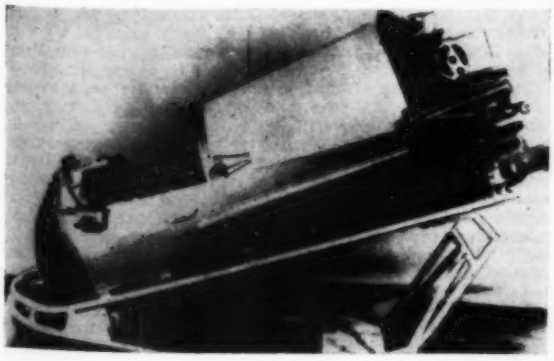
*Another deep-space probe (described as an "early design") suggested by Avco: 1, arc-jet engine; 2, $H_2$ tank; 3, arc-jet coolant radiator; 4, nuclear power supply; 5, condenser for Hg turbine driving electric generator; 6, payload; 7, aerials*

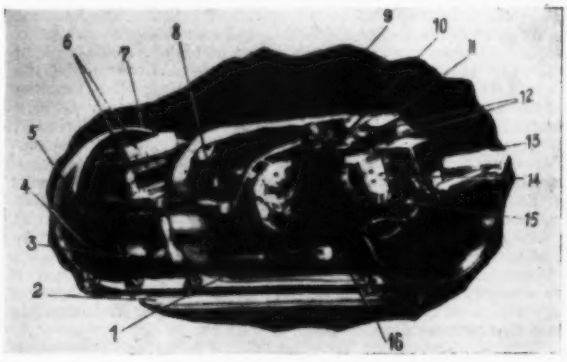
## GE'S BIG PLUG NOZZLE

In our issue dated February 12, 1960, we published an introduction to the technology of plug-type rocket engines. The plug nozzle essentially involves injection of the propellants around the base of a truncated cone and expansion of the jet down the sides of the cone. We reported that, although a large number of American organizations are engaged in theoretical studies and rig testing, only GE and NASA appeared to be in a position to translate the concept immediately into hardware.

NASA have now announced that they have placed a contract with GE for a complete flight engine with a sea-level thrust of 50,000lb. Basic research already completed at the Malta Test Station confirms the hope that the short plug nozzle is only fractionally less efficient than the optimum (not truncated) design, much lighter and readily amenable to asymmetric injection for steering purposes.

*Two photographs radioed from Moscow on September 4 depicting the "doghouse" recovered from orbit on August 20. Left, the exterior, the capsule being the cylinder at the right-hand end of the container. Right, the interior: 1, air cylinder; 2, catapult firing system; 3, RDF unit; 4, battery for heating test glass with microbes; 5, storage battery; 6, research experiments; 7, catapult mechanism; 8, "movement mechanism"; 9, sealed cell for the two dogs; 10, microphone; 11, RDF aerial; 12, air in/out valves; 13, TV camera; 14, mirror; 15, ventilation; 16, automatic feeder*





# European Congress of Aviation Medicine

## FURTHER SUMMARIES OF THE PAPERS

AT the fifth European Congress of Aviation Medicine at the Royal College of Surgeons two weeks ago, Mr Peter Masefield presented a paper entitled *Some Points on Supersonic Flight*. In doing so he cast a stone into previously unruffled waters, for the Congress—briefly reported in last week's *Flight*—had already heard 29 papers, and in those which referred directly to the cabin environments of supersonic and hypersonic aircraft the unanimous assumption had been that these aircraft would have windowless passenger compartments. Mr Masefield, as an ex-airline operator, was convinced that most passengers would not fly in windowless aircraft. If the doctors and engineers seriously intended to give them windowless aircraft they would have to think again.

Thus there arose a lively controversy. Mr C. S. R. Marshall, of the Hawker Siddeley advanced projects group, whose paper was reviewed last week, had said that both the skin temperatures and aerodynamic shape of Mach 2+ airliners would preclude the provision of passenger windows. He dwelt not at all on the structural weakening that windows entailed, and which occupied the attention of other speakers. The flight deck windows would be covered by shutters at all but low speeds immediately after take-off or on the approach, for at Mach 2.2 the outside temperature on the transparencies would be about 150°C, and the resulting ultra-violet radiation harmful to the pilots' eyes.

Air Cdre W. K. Stewart, of the RAF Institute of Aviation Medicine, disapproved as a physiologist of windows in supersonic aircraft. Any chance of decompression must be designed out of supersonic airliners, which would cruise at about 60,000 to 70,000ft, and the omission of windows was a prerequisite. There would be psychological difficulties in this—in accelerations the passengers might think the aircraft was diving into the ground—but with attention to passenger psychology and comfort, and to the elimination of noise and the provision of television displays to compensate for the lack of windows, he was sure that supersonic travel would be pleasant.

### Demand for Windows

Then Mr Masefield, the only speaker at the Congress with experience as an airline operator, cast his stone with a demand for windows. He demanded, too, that work should begin on a Mach 3 airliner, rather than a Mach 2 machine—which in the context of the 1970s, when it would come into service, would be "commercial suicide." A Mach 2 airliner with a conventional light alloy structure could be started tomorrow, with every expectation of technical success, but that would serve us ill if the USA or USSR produced an aircraft at about the same time which was 500 m.p.h. faster. A Mach 3 airliner, which would require a steel and titanium structure to resist skin temperatures of about 280°C, would be a greater technical gamble within the bounds of present knowledge, but it would offer greater commercial security.

He advocated 3½hr as its desirable endurance, for with a range of 5,500 miles it could connect any two spots on the globe with only one re-fuelling stop. Three-and-a-half hours was the maximum endurance desirable in any commercial aircraft, as this was the "posterior limit" beyond which the human bottom was not comfortable in any chair, however well designed.

Mr Masefield admitted that decompression or fuel leakage in such an aircraft would be lethal, and said there must be intensive research into window and fuel tank sealing methods. Load factors would be all-important, and to guarantee them the aircraft *must* have windows. Engineers and operators would just have to accept the sacrifices in structure weight and cost.

Certain specialists who followed Mr Masefield had some things to say about cabin environments in supersonic airliners. Gp Capt D. McK. Kerslake, head of the climatic division of the Institute of Aviation Medicine, said that the optimum design environment may be different from the physiological ideal, for provision of the latter may involve disproportionate reductions in operational efficiency. It was, in any case, impossible to please all passengers, whose ideas of ideal cabin conditions may vary widely—men, generally, being happier in higher temperatures than women.

More must be known about the psychological effects of discomfort—at present we do not know whether the effects of several simultaneous discomforts are additive, or whether the total measure is the effect of the greatest discomfort, be it an unsuitable seat, unfavourable temperature or rarified air.

Hot fuselage walls would affect the environment unless compensated for either by refrigerating the cabin air or by improving insulation. Two-skin walls with a vacuum space and of great thermal resistance were a possibility. There must be improved insulating methods, for insulation would be cheaper than removing heat from the cabin air.

With good insulation there would still be a need for cooling, to remove heat generated by occupants. It would be advantageous to limit as much as possible the entry of fresh air into the cabin; air drawn from the cabin would be cooled, conditioned and re-circulated. The removal of dust and smoke was easy; water vapour and carbon dioxide posed a greater problem.

Passengers would each lose by evaporation an average of about 50gm/hr of water in a temperature of 74°F; with no water vapour removed and no fresh air admitted, the atmosphere in a 120-seat aircraft would be saturated in 15 minutes. For most of a flight lasting several hours, it would be necessary to remove vapour at the same rate as it was generated. Failure of the conditioning plant would be very serious—in the event of a cooling failure it might be necessary to descend and slow down to prevent a "run-away" in cabin temperatures, and this in turn might prevent the airliner reaching its destination. Any possibility of such a failure must, therefore, be designed out.

### Windowless Structure

This could be done by triplicating the cooling plant, said Dr G. Bennett, in a later paper. Dr Bennett is research medical officer of BOAC, and he is a firm proponent of the windowless structure. He thought that skilful cabin décor, television displays and possibly artificial windows lit from behind would deal with psychological aversion.

Ozone would be present in air admitted to the cabin at cruising altitudes, said Dr Bennett, caused by the ionization at those altitudes. The level of contamination, at about six parts per million, would be toxic. The heat generated by the aircraft's passage would partially convert the ozone to oxygen, but at the comparatively low temperatures of a Mach 2 aircraft ozone separation equipment would still be necessary.

Another high altitude factor affecting the crews' health was cosmic radiation, but this would only be significant at above 80,000ft, and at the cruising altitudes of the first generation supersonic transports would present no hazard if crews did not exceed 1,000 flying hours a year.

Operators must insist strongly that internal noise levels should not exceed those experienced at present—otherwise, Dr Bennett thought, they would rise. He believed that by 1970, rearward-facing seats and stronger floor structures would have become mandatory for crash injury protection. In the designs currently projected, the provision of adequate escape exits would be difficult.

A very wide range of subjects was covered in more than 60 papers presented during the four working days of the Congress, and many were concerned with the immediate problems and practices of aero-medicine. Many speakers talked of improved aircrew selection methods which were being developed throughout the world by military and civil operators; and to underline the importance of unceasing vigilance in medical examinations, there were tales of disturbing medical failings among operational flyers.

### Coronary Disease

At the first Congress session, AVM Sir Aubrey Rumball, an RAF medical consultant, lectured on the detection of coronary artery disease in its earlier stages, and examined its risk in airline pilots. Knowledge of symptomless coronary disease in young adults was comparatively new, he said; but the incidence of coronary artery diseases was increasing throughout the world, and they accounted for 40 per cent of all deaths in Britain. When degenerative heart diseases were counted, the figure nearly doubled.

Both Britain and the United States had made autopsies of fatal crash casualties, to determine whether coronary attacks among pilots were responsible. In the 93 autopsies made by Wg Cdr Mason, of the RAF Institute of Pathology, 21.5 per cent of the subjects were found to have second or third degree atheroma—degenerative changes in artery walls. Forty-three per cent had atheroma to a minor degree, and 35.5 per cent were completely free. These figures were almost identical to those recorded in similar US studies. Wg Cdr Mason's conclusion was that none of the accidents had been caused by acute coronary attack. In the years 1949 to 1958, thirty-six RAF pilots had suffered coronary occlusions, but there was no incidence of this affecting a pilot while flying, although there were cases of its happening just before take-off and after landing—and in one case, to a pilot resting in flight. We could not entirely rule out cases in pilots flying solo who crashed, but such cases must be very rare.

In 1954, the RAF began a survey by electrocardiograph of the continuing health of 660 fit men, between the ages of 19 and 54, and this was still in progress. An interim conclusion was that we could expect about two occlusions a year in 1,000 subjects, at a

mean age of forty—the risk increasing with age. "It is impossible not to infer," said Sir Aubrey, "that cigarette smoking increases the tendency of blood to clot in coronary arteries already the site of atheroma." There was a connection, too, between ischaemic heart disease and high levels of serum cholesterol—a crystalline substance of a fatty nature—in the blood. When in exeess of 275mgm/per cent this increased fourfold the chances of developing coronary artery disease.

AVM Rumball concluded that aircrew selectors had a duty to recognize the factors which tended to divide the population into those whose chances of developing coronary occlusion were small, and those in whom the chances were appreciable. Personnel for key positions, or pilots for solo missions, should not be drawn from the poor risk group.

In a subsidiary paper Dr W. Kornaszewski, director of the Polish Aeronautical Medical Examination Centre, confirmed AVM Rumball's statement about serum cholesterol. In Poland two groups of civil airline pilots, in the 31-40 and 41-50 age groups, had been examined. Cholesterol and esterified fatty acids (lipids) were in greater concentration in the circulatory systems of the older group and their arteriosclerotic possibilities were found to be greater. So, too, was their blood pressure.

The words "coronary occlusion" cropped up again in a short but fascinating talk by Maj S. E. Neeley, USAF. He has carried out a thorough analysis of all USAF flying accidents in 1959, which numbered 672, or 8.2 per 100,000 flying hours, the lowest rate since 1940. He eliminated all accidents in which aircraft uncontrollability was the key factor, and then determined the patterns of interference with pilots' controlling ability in the other accidents. Such interference, usually combined with contributory factors, accounted for 50 per cent of major accidents, and fell into four categories: spatial disorientation, or vertigo, caused by a rapid change of motion in all three planes, control being lost without known reason or confusion between the pilot and his instruments; misorientation; distraction and incapacitation. In the five cases of pilot incapacitation, two were caused by coronary occlusion and three by hypoxia.

Medical consultants of both KLM and Air France made contributions to the Congress. Dr K. Vaandrager, of KLM, spoke of a new approach to pilot selection, to reduce the present figure of 60 per cent of civil air accidents being caused by pilot error. In parallel with the normal medical and psychological examinations, KLM's selectors attempt to determine a candidate's personal stability, by determining such factors as obvious behaviour; tolerance of frustration; self-respect and assurance; genealogical background; sense of responsibility and the degree of introversion and extroversion. Dr Vaandrager's compatriot Dr G. Puister expressed the conviction that use of the electroencephalogram (understandably abbreviated to EEG) was of great value in the psychological selection of candidates. He has found that there are specific brainwave patterns, not pathological in themselves, which are not seen in pilots of high professional standard, but which occur in a high percentage of candidates who are not accepted under the normal selection procedure or, if accepted, fail in training or are assessed as mediocre pilots.

It is impossible to report in the available space all the papers worthy of attention, and we have concentrated on only some of those of direct relevance to commercial air transport. There were others of airline interest and apart from these there were even more of great interest but relevant only to military flying or space flight. French delegates told of interesting experiments in the development of ventilated suits and full-pressure flying gear, and RAF aero-medical specialists presented several papers on their experimental work. A German, Dr H. von Diringshofen, postulated a new type of instrument presentation and instrument flying training which would lessen the chances of military pilots suffering spatial disorientation and losing control in instrument flight during combat. United States delegates showed some very interesting films on the development of Project Mercury and other re-entry vehicles, and on an ejection survival capsule developed for the B-58 Hustler supersonic bomber. Dr E. C. Poulton, of the Medical Research Council's applied psychology unit, warned against the danger of over-simplified laboratory experiments in psychology.

It was left to a Russian physiologist, Dr A. Vorobiev, who presented one of the last papers, to sound a warning that physiological experiments too may be over-simplified or over-specialized, and to indicate that the capabilities of contemporary airline crews might be seriously extended.

Individual factors causing functional changes in pilots in flight —noise, accelerations, vibration, hypoxia, and so forth—had been intensively studied, he said; but there had been too little study given to the overall effect of these factors, working together, on long flights. Accordingly, automatic equipment was developed to record pilots' basic reactions to the various phases of flights over trunk routes. Data was recorded on 65 pilots in more than 500 scheduled flights, of up to nine hours' duration and at heights between 16,500 and 33,000ft in Tu-104 turbojets and Tu-114 and Il-18 turboprop airliners. For comparative purposes, identical studies were made of aircrews operating Il-12, Il-14 and An-2 piston-engined aircraft on scheduled runs.

By this means, the particular effects on pilots' vegetative systems of flights incorporating the latest gas turbine techniques were recorded. It was found that the functional changes were most marked in pilots flying the jet and turboprop aircraft. The average Tu-104 captain's blood pressure on the approach to land was 22mm of mercury above that of his Il-14 counterpart, and his respiration was anything between 12 and 19 breaths a minute faster. Of course, his pulse rate, blood pressure and respiration were quite similar to those of the average piston-engined aircraft captain.

In staged flights totalling more than eight or nine hours' flying, with intermediate stops, some cases were marked by a relative reduction in blood pressure, showing the onset of general fatigue. Grip on the wheel was found to be one-and-a-half or twice as tight as normal. Functional changes in the cardiac-vascular system were found to be more manifest in pilots suffering from the early stages of hypertonia (muscular tension), while those pilots who showed the more marked vegetative reactions developed fatigue symptoms more rapidly and lost efficiency sooner. On long flights, oxygen starvation—caused by the pressurization being to only 6,000 or 8,000ft levels—could not be ruled out as a cause of functional changes.

Dr Vorobiev suggested that these reactions in the pilots' systems could be evened out if pilots breathed oxygen not only at high altitudes but during critical phases of the flight, particularly during the landing phase. Another justification for the provision of oxygen was the high accelerations acting on contemporary airline crews in specific flight phases, with the inhibition of breathing they entailed.

One of Dr Vorobiev's most interesting findings was that functional changes were more acute in pilots flying passenger aircraft than in those piloting freighters of the same type over the same routes. He attributed the racing pulse, the quickened breathing, to an increased sense of moral responsibility.

With the world's aviation doctors working so keenly for the development of ever-safer flight, and manifestly so eager to share the fruits of their labours with their counterparts the world over, they, too, clearly do not lack a sense of moral responsibility.

R. R. R.

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## *The Thermals of Texas*

(*continued from page 483*)

What of US gliding? Here is a country with more exciting and more entirely unexplored air than I thought could still exist, with roads and telephones and ground facilities, with a wealthy people possessing unexampled talents of technology and energy. Yet the number of sailplanes in it are about the same as here, and the amount of flying they do is much less. Why? It seems rather nerve after a three weeks' visit to express views, but so many people, both here and there, have asked for them that I will try.

One obvious answer lies in the very size of the country, and the difficulty of organizing a gliding movement in any central way. In these circumstances the talented folk whose opposite numbers in England have managed to get together and organize a network of self-control satisfactory to our authorities, and some reasonably equipped gliding clubs, have been driven in on their individual resources. Thus we see unbelievable aircraft like the HP-8 designed, constructed and flown to victory by one man (note the figure eight—Dick Schreder has previously built seven other prototypes!); and the SISU, well-nigh incredible creation of one man working with a few elementary tools in his own garage, and many others.

But a sport which requires supermen for its participation cannot expand beyond a certain point, and expansion only comes when things such as club-houses (permitting an ordinary man to be a glider pilot and also be happily married), hangarage and repair facilities become available. Up in Elmira Paul Schweizer has for 20 and more years been working to this end, by producing his well-known range of gliders. But, here in Texas, Elmira was 3,000 miles away. Any damage to one's craft had to be repaired by the pilot or such friends as he could hope to retain; whilst wives and children standing in the middle of the sun-drenched dusty field might easily die of thirst and sunstroke while hubby disported himself overhead.

However, after nearly three decades in this field, I am getting a nose for it. I predict the sport has now got over top-dead-centre, and that from now in the USA gliding will accelerate exponentially. And this meeting, acknowledged by all to have been the most successful to date, will have helped to achieve this. Certainly Kitty and I will never forget it.

# CORRESPONDENCE

*The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. The names and addresses of the writers, not for publication in detail, must in all cases accompany letters.*

## Twin Pioneer Payload

I HAVE been reading the figures published in the table on page 326 of *Flight* for September 2 in which Twin Pioneer data are included, and must take you to task regarding the figures published. For the Twin Pioneer, the following figures are correct:—

Internal cabin dimensions: width, 6ft 0in; height, 5ft 9in; length, 22ft 8in; payload, 3,530lb.

This payload figure is the capacity payload based on 16 × 160lb passengers and a freight and baggage density of 10lb/cu ft and can be carried with full allowances for 70 st miles IFR by a Series 3 Twin Pioneer. Please note that the 3,000lb payload you quoted for the Short SC.7 is also apparently capacity payload, which (reference *Flight* for August 26, page 311) can be carried with average fuel allowances for 115 st miles VFR and 70 miles IFR, whereas the 2,600lb you quoted for the Twin Pioneer is the payload which can be carried 450 st miles with full allowances in IFR conditions. The maximum weight for the Series 3 Twin Pioneer is 14,600lb, not 14,000lb as quoted in the table.

I have no wish to decry the Short SC.7, which would appear to be a very useful type of aircraft, but the figures quoted for this aircraft are obviously estimates, which may be correct; but, on the other hand, those we are quoting for the Twin Pioneer are facts.

While writing, you may be interested to know that full-scale fatigue testing is still in progress and, to date, we have exceeded 24,000 hours' safe life at an operating height of 3,000ft, based on flights of 45min duration. From the records received from Twin Pioneer operators it would appear that the average operating hours per year amount to around 1,250, which gives an aircraft life, at the present moment, of 19 years, even at this low altitude; and, of course, the fatigue rig is still running.

Prestwick, Ayrshire R. McINTYRE,
Director and Chief Engineer, Scottish Aviation Ltd

## Britain's Space Dilemma

I HAVE just received my copy of your most interesting (and to me, as an Englishman, depressing) "Space Special" issue of August 5. The two articles "Britain's Space Dilemma" and "Britain's Booster" spotlight very clearly our present unhappy position; we could as a nation go out into space with the equipment and knowledge that we already have, but are being prevented from doing so by Government shortsightedness. The answer to the question posed in Mr Owen's last paragraph on page 183 is absolutely obvious; nothing is going to stop the human race exploring the universe beyond this planet as soon as the necessary equipment is developed, in the same way that it explored (and eventually made use of commercially) the atmosphere around the planet. If we in Britain want to share in the future progress of humanity we have got to enter this field of exploration now. That there will be future economic benefits to those who do so is certain; what they will be is not so certain—Santos-Dumont or the Wrights could not have forecast today's intricate network of airlines, whose effect upon the world's economy has been incalculable.

The Government, it seems, has not the faith to expend money on a project which cannot at present justify itself financially, whatever the ultimate rewards may be. I believe that (in spite of the image of the "hard-headed businessman" interested only in profits, put about by certain sections of the Press) the leaders of British industry have faith and vision beyond those of Government departments, and I should like, if you will permit me a few more lines of your space, to suggest a possible course of action that they might follow.

As far as I know, there is no law to prevent any person or organization from operating any rocket or space vehicle—provided, of course, that this is not done with any hostile intent towards other powers. I therefore suggest that a company should be set up by the FBI or SBAC called "Space Exploration Ltd" or something of the sort; this would be registered as a non-profit-making organization, and would therefore be eligible for substantial tax benefits (any profits that resulted from its activities would be ploughed back into further research). As its activities would naturally have to dovetail closely with those of the Government, even though the latter gave it no financial support, the Minister of Defence should be asked to appoint a full-time chairman, and possibly one or two other directors.

The finance of the company would come from contributions from industry and individuals with large incomes, covenanted to it for a period of not less than seven years, and therefore subject to a much-reduced rate of tax. It seems to me that the use of such methods would raise large sums of money (bearing in mind the amounts paid in tax by companies and rich men in any normal year) without costing the contributors much (e.g., the raising of over a million pounds in a year for the restoration of Westminster Abbey); they would never see the money anyway. It might even be possible to complete and fire some Blue Streaks independently of the Government; better still, the Government might be shamed into doing the job properly itself.

Kenley, Surrey. WM R. MATTHEWS

## In Much-sought-after Neighbourhood . . .

REFERRING to the current controversy about noise at London Airport, surely none of the residents who complain so strenuously about the noise and corresponding loss in value of their properties can be really so averse to living in the area. If things are as bad as they make out then surely people would be trying to move away from the area.

Instead, exactly the opposite appears to be the case. I am currently trying to find accommodation near my work at the airport, but find that accommodation within ten miles is virtually unobtainable.

It would seem, therefore, that local residents are either trying to throttle the future expansion of London Airport as a world centre, or are just staying a little longer in the hope of obtaining even higher prices for their properties.

Emsworth, Hants BRIAN T. ESTILL

## Low Tu-124, High Mi-4

HAVING just received my copy of your July 8 issue, I was much interested to examine the first-released photograph (page 33) of Mr Tupolev's latest creation, the prototype (?) of his 44-seater turbofan Tu-124. I was particularly struck by the fact that the wings are apparently a mere five or six feet from ground level—unless, of course, it's an optical illusion created by the angle from which the picture was taken. But, there it is—one of the three Russians standing in the extreme right of the picture appears to have his arm resting on the top of the wing. [No optical illusion, but a combination of short-legged undercarriage and pronounced anhedral.—Ed.]

Reference your news item from India, stating that a Mi-4 helicopter was demonstrated before Mr Nehru, it was presumably intended to show the Mi-4's paces by landing it in the Himalayas around the 14,000ft mark. The Soviets are a poor second on this occasion because, in May of this year, Igor Sikorsky's record-breaking S-62 was likewise demonstrated, delivering a payload of 2,000lb at 14,000ft in the Himalayas.

Nairobi, Kenya DENNIS M. POWELL

## Timber Hangar at Gatwick

WE have been informed that your issue of June 24 stated that the timber hangar for Overseas Aviation at Gatwick Airport, for which structure we are the architects, cost approximately £300,000.

The present hangar is merely Stage 1 of an eventual £300,000 development which will include three hangars, ancillary workshops, offices and pre-stressed concrete apron.

Thus, apart from its functional advantages, the present hangar can rate as one of the most economical developments of recent years. This applies not only to first cost but also to maintenance, which is virtually nil.

London, SW8 D. T. MYERS,
P. and D. T. Myers, Architects

## FORTHCOMING EVENTS

Sept. 12-18. Battle of Britain Week: Exhibition, Horse Guards Parade, London; RAF Airfield "At Homes," September 17.
Sept. 21. Kronfeld Club: "Flying in the US Nationals," by Philip Wills.
Sept. 21. RAeS (Coventry Branch): "Relationship Between Theory and Practice in Aircraft Structural Problems," by A. J. Troughton.
Sept. 25. Milan Aero Club: Helicopter Rally.
Sept. 26-Oct. 1. AGARD Structures and Materials Panel Meeting, Athens.
Sept. 28. Kronfeld Club: Meteorological Discussion.
Sept. 28. RAeS (Isle of Wight Branch): "Anti-Gravity and Flying Saucers," by L. Cramp.
Oct. 3-7. AGARD meetings (including 10th General Assembly), Istanbul.
Oct. 7-8. British Institution of Radio Engineers: Aircraft Electronics Convention, Bristol.
Oct. 8-9 FAI Rally, Barcelona.
Oct. 11-12. Aerodrome Owners' Association: Annual Conference, Folkestone.

# FLIGHT

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